HEATH

Schlumberger

EU-200 SERIES
APPLICATIONS GUIDE

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HEATH COMPANY
BENTON HARBOR, MICHIGAN 49022
a Schlumberger company

595-1485-02

EU-200 SERIES

APPLICATIONS GUIDE

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Section 1

INTRODUCTION

Latest technology in electronic instruments research and development has resulted in an extensive series of highly-versatile electronic instruments. These Signal-Conditioning Modules are functional instruments which may be integrated in a variety of systems to measure many physical and electrical parameters with extremely good precision. This Manual provides information that is very useful for set up and interconnection of modules for most of the applications listed. Each application is described in a "systems" manner along with the specifications for each "system." All products in the line have a model number between 200 and 299, and are referred to as the 200-Series. Examples of the instruments which may be synthesized with 200-Series Signal Conditioning Modules are as follows:

Digital Thermometer
Electronic Thermostat
Expanded Scale Recording Thermometer
Multiple Channel Recording Thermometer
Digital Voltmeter
Programmable Strip Chart Recorder
Analog Multiplexer/Recorder
Digital pH/pIon Meter
Expanded Scale Recording pH/pIon Recorder
Multiple Channel pH/pIon Recorder

This is a partial list of the many instruments possible with 200-Series Modules. The user who has a varied set of requirements will undoubtedly be able to devise many additional instruments.

This Manual augments the manual provided with each individual module.

Section 2

APPLICATIONS

The EU-200-Series is an extensive assortment of basic electronic instruments from which innumerable "systems" can be designed. This section of the manual contains a general description of several typical systems. Each application is fully illustrated and detailed, including the pertinent specifications for each system.

Listed below are the model numbers and names of the components in the current "200-Series," and a chart showing the combinations used in each application described on the following pages.

EU-200-01	Potentiometric Amplifier
EU-200-02	DC Offset Module
EU-200-91	Limit Detector
EU-200-92	Multiplexer
EU-200-81	Servo Amplifier Patch Module
EU-205-11	Strip Chart Recorder

Accessories –

SU-200-03	Blank Module
SU-200-GA	Gimbal Accessory
SU-200-RM	Rack Mount
SU-205-01	Centimeter Chart Drive
SU-121-22	Retransmit Potentiometer
SU-20-23	pH Probe
SU-200-TA	Temperature Probe
SU-200-TB	Temperature Probe
SU-200-TC	Temperature Probe

SYSTEM APPLICATION	200– COMPONENTS USED							205–
	–01	–02	–30	–41	–62	–91	–92	11
Digital Thermometer				1	1			
Electronic Thermostat				1		1		
Expanded Scale Recording Thermometer	1	1		1				1
Multiple Channel Recording Thermometer				1			1	1
Digital Voltmeter	1				1			
Programmable Strip Chart Recorder	1	1						1
Digital pH/pIon Meter			1		1			
Expanded Scale pH/pIon Recorder		1	1					1
Multiple Channel pH/pIon Recorder			3				1	1

DIGITAL THERMOMETER

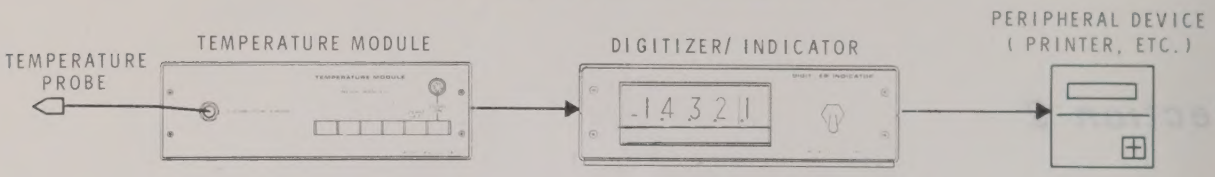

Figure 2-1 Block Diagram of the Digital Thermometer

A Temperature Module, Digitizer/Indicator, and a Temperature Probe* combine to produce a very precise and accurate Digital Thermometer with 4-1/2 digit readout. Four overlapping, linear temperature ranges allow unlimited variation in application through a dynamic range from –30°C to 100°C. Automatic decimal point control from the Temperature Module results in a direct temperature indication on the Digitizer; and since the Digitizer is bi-polar, negative temperatures are also indicated directly. Resolution and Stability are the equal of most laboratory standard instruments.

Four decades of 1-2-4-8 BCD plus an indication of 0 or 1 in the fifth decade are available at the rear of the digital panel meter to drive external devices (e.g. digital printer). In addition, a print command output is also provided to key external printing devices for BCD information acceptance. All of these outputs are compatible with TTL or its equivalent. A connector is supplied with the Digitizer/ Indicator which may be used to make an output cable for access to these outputs. For more detail, refer to the manual that accompanies the digital panel meter.

THEORY OF OPERATION

Figure 2-1 represents the block diagram of a Digital Thermometer. The resistance of the thermistor temperature probe changes with a change in temperature and regulates the output of the Temperature Module. This produces a linear voltage representative of the temperature (i.e. 10 millivolts per degree). The Digitizer/Indicator displays the output voltage from the Temperature Module with 0.01°C resolution. In addition to the temperature output, the Temperature Module provides resistor-selected automatic decimal point position control for a direct temperature indication. As previously mentioned, temperature data is supplied by the digital panel meter for all BCD TTL compatible peripheral devices.

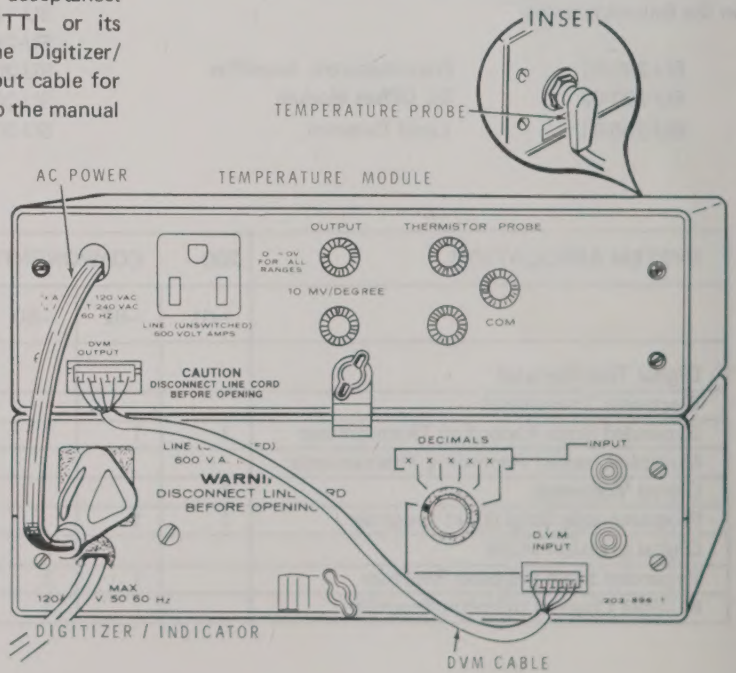

Figure 2-2

Rear panel interconnections and switch position required for operation as a digital thermometer. The inset shows the front panel probe jack with a temperature probe connected.

*Compatible with all 700-series YSI (Yellow Springs Instrument Company) probes.

SETUP PROCEDURE

Refer to Figure 2-2 and interconnect both modules with the DVM cable supplied with the Digitizer, and switch the rear panel selector to the DVM INPUT position. Plug the Temperature Module line cord into the Digitizer power receptacle. The Digitizer power switch is now the Master power control. Connect the Digitizer line cord to a suitable power source. Plug a temperature probe into the front panel jack of the Temperature Module and select the desired temperature range, then switch both units ON. Hereafter, only the Digitizer power switch need be operated. The temperature indicated will be direct for all ranges (both Centigrade and Fahrenheit positions).

SPECIFICATIONS

INPUT PROBE

Type	SU-200-TA, SU-200-TB, SU-200-TC, and all YSI 700-Series probes.
Dynamic Range	–30°C to 100°C.
Interchangeability Error	±0.15°C.
Linearity*:	
–5°C to 45°C	±0.1°C (module calibrated at this range).
–30°C to 50°C	±0.25°C.
0°C to 100°C	±0.3°C.
32°F to 200°F	±0.7°F.
Time Constant	Refer to specifications for individual probe.

INSTRUMENT

Stability:	
Temperature	0.01°C/°C ambient.
Line Voltage	0.001°C/volt.
Precision	±0.06°C for ±5% line variation ±5°C ambient change, 80% relative humidity maximum and over a one-week period.
Display	–30.00°C to 100.00°C.
Resolution	0.01°C.
Maximum Instrument Calibration Error	±0.1°C or ±0.3°F for uncalibrated ranges.
Maximum Calibration Error Between Ranges	±0.1°C or ±0.3°F for uncalibrated ranges.
Module Operating Temperature	10° to 40°C ambient.
Power Requirements	105-130 volts, 50/60 cycles, 14 watts maximum. (Can be rewired for 210-260 volt operation).
Dimensions	8-3/4" wide, 10-3/4" deep, 6-1/8" high.

*Refer to Probe Curves in the Temperature Module Manual.

ELECTRONIC THERMOSTAT

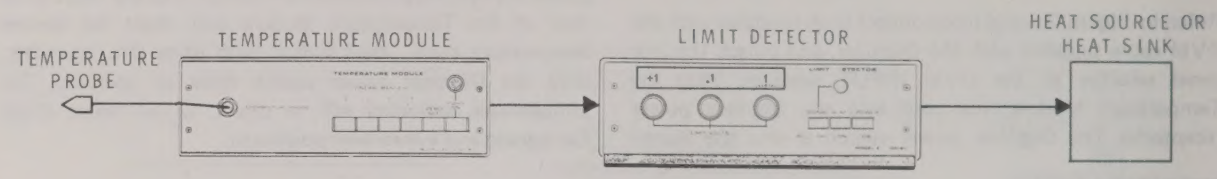

Figure 2-3 Block Diagram of the Electronic Thermostat

Very precise control of a thermal medium between –30°C and 100°C is possible when the Temperature Module, Limit Detector, temperature probe*, and the necessary thermal input/output device are integrated into a system. Two separate control outputs are provided, as well as a front panel lamp and an internal buzzer for visual and audible limit indications. One of the control outputs is a set of normally-open and normally-closed relay contacts that change state when the temperature exceeds the preset limit. The second control output consists of a pair of true and complementary TTL gates which switch their output level when the preset limit is exceeded. Logic response time is better than 1 millisecond when the temperature is 1°C or greater out of limit. However, a preset level is easily maintained within ±0.15°C (typical).

THEORY OF OPERATION

Figure 2-3 represents the basic Electronic Thermostat. The resistance of the thermistor temperature probe changes with a change in temperature and regulates the output of the Temperature Module. This produces a linear voltage representative of the temperature (i.e. 10 millivolts per degree). The Limit Detector compares the output voltage from the Temperature Module with an internal reference voltage which is preset by the front panel Limit switches. When the Temperature Module output exceeds the preset limit, the Logic gates change output level and the relay changes state (energizes lamp and buzzer circuits, and changes relay contact state on rear panel). This sequence of events will switch the heat source or heat sink either ON or OFF to bring the temperature within limit.

*Compatible with all 700-series YSI (Yellow Springs Instrument Company) probes.

SETUP PROCEDURE

Refer to Figure 2-4 and interconnect the Output of the Temperature Module and the Input of the Limit Detector with the dual banana cable provided with either module. Connect the line cord from the Temperature Module into the power receptacle on the rear of the Limit Detector. Then connect the line cord from the Limit Detector to a suitable power source. Plug the temperature probe (SU-200-TA, SU-200-TB, SU-200-TC, or any YSI* 700-series probe) into the front panel jack of the Temperature Module and select the desired temperature range. Set the limit control-point on the Detector front panel. (The Temperature Module output is 10 millivolts per degree.) Finally, connect the thermal input/output device to the required control output. (The Relay connector provides access to normally-open or normally-closed contacts that change state when an over-limit condition occurs. The Logic output provides a TTL compatible logic "0" and "1" that will also change state for over-limit conditions.) With this setup, it is now possible to maintain a predetermined thermal level to a very narrow range by cycling a heater or cooler ON and OFF with the Limit Detector.

If a thermal window must be maintained, two Limit Detectors are required. Interconnect the Input of the second Detector with the unused Input of the first Detector. Connect the required thermal input/output device to each Detector and set the limit level on each unit for the desired window.

To monitor the temperature, connect the Temperature Module to the Digitizer/Indicator as described in the Digital Thermometer System. The Limit Detector will not affect the accuracy of the Digitizer/Indicator.

*Yellow Springs Instrument Company

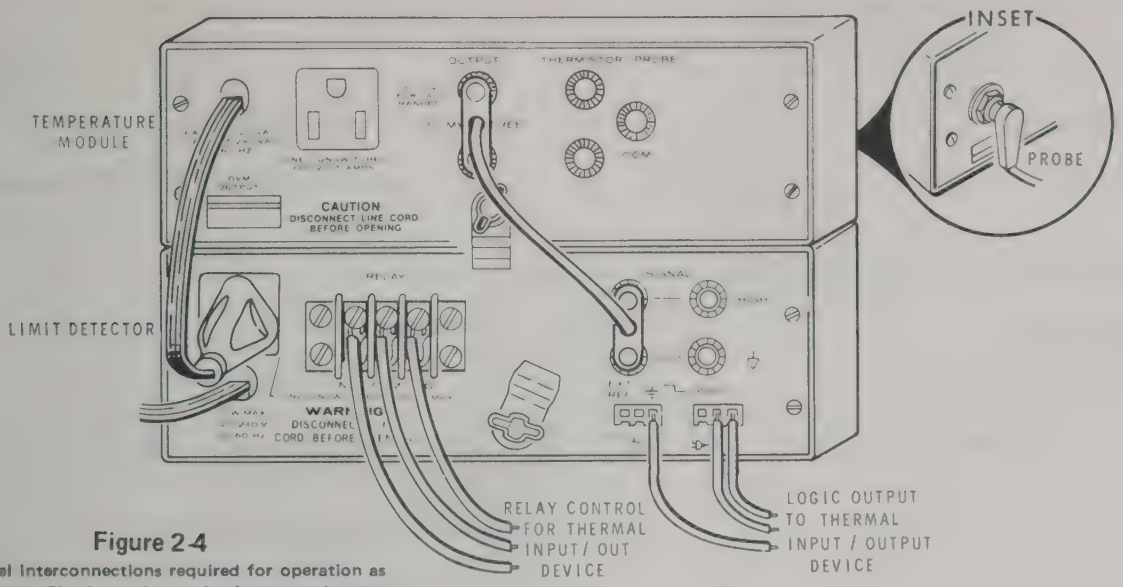

Figure 2-4

Rear panel interconnections required for operation as a thermostat. The inset shows the front panel probe jack with a temperature probe installed.

SPECIFICATIONS

Precision	±0.15°C for ±5% line variation, ±5°C ambient change, <80% relative humidity, over a one week period.
Input Probe:	
Type	SU-200-TA, SU-200-TB, SU-200-TC, and all YSI 700-series probes.
Dynamic Range	–30°C to 100°C.
Interchangeability	±0.15°C.
Control Outputs:	
Maximum Relay Load (form C contacts)	2 amperes, resistive.
Relay Response Time (form C contacts)	≤10 ms when input signal is 10 mV (1°C) over limit.
Logic Output	TTL levels capable of sinking 14 mA at a 0 level. Logic 0 ≤0.4 volts. Logic ≥2.4 volts but ≤5.5 volts.
Logic Response Time	≤1 ms when input signal is 10 mV (1°C) over limit.
Maximum Instrument Calibration Error	±0.8°C or ±1°F for uncalibrated ranges.

Maximum Zero Set Shift Between Ranges	±0.1°C or ±0.4°F for uncalibrated ranges.
Comparator Hysteresis	<0.01°C.
Comparator Drift	<0.01°C/°C ambient (after 30 minute warmup).
Reference Voltage Drift	0.025% of setting or 0.01°C/°C, whichever is greater (after 30 minute warmup).
Long Term Reference Calibration Drift	0.2% maximum.
Line Stability	0.003°C/volt.
Instrument Operating Temperature	10° to 40°C ambient.
Power Requirements	105-125 volts, 50/60 cycles 14 watts maximum. (Can be rewired for 210-250 volt operation.)
Dimensions	8-3/4" wide, 11-1/8" deep, 6-1/8" high.

FEATURES

Limit Indication:

Visual	Front panel lamp.
Audio	Buzzer (front panel defeat switch).
Relay contacts	Form C provided on rear panel, change state when limit is exceeded.
Logic output	Both true and complement outputs are available at the rear panel connector, with provision for interconnecting two or more modules to obtain one logic output.

EXPANDED SCALE RECORDING THERMOMETER

For research applications where very high resolution and precision are required, the Expanded Scale Recording Thermometer is equal to the task. The components needed to produce this instrument are a Temperature Module, temperature probe*, and a Programmable Chart Recorder (Potentiometric Amplifier, DC Offset Module, and Strip Chart Recorder). Four overlapping, linear temperature ranges and nine ranges of expansion allow unlimited variation in application through a dynamic range from −30°C to 100°C (0.1°C full span to 130°C full span). Refer to the Specifications for a partial list of range vs resolution.

Along with its high performance temperature recording capability, the Chart Recorder is fully programmable. A readily accessible connector block on the rear panel provides the following inputs and outputs: Inputs-- Chart Drive, Servo, Pen Lift, Chart Control, and Pen Motor. Outputs-- Slidewire, TTL-compatible Chart Drive, Reference Supply, Zero Control, Chart and Servo ON, and Servo Null Signals. All functions are controlled by logic circuits or contact closures.

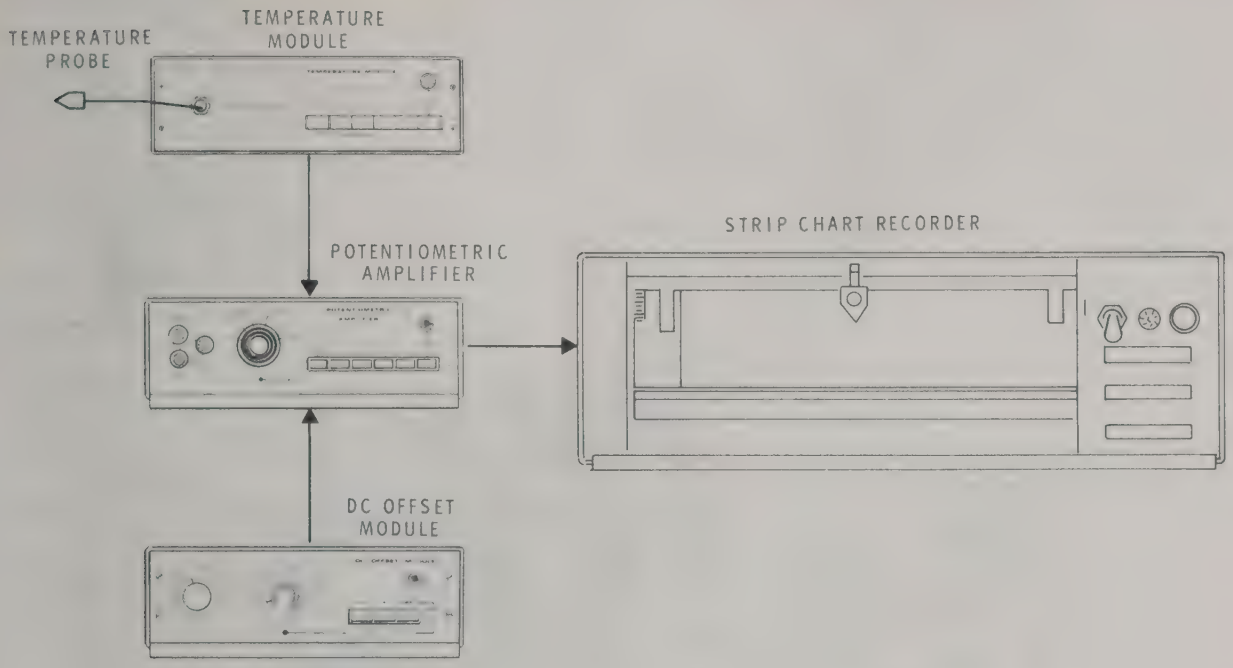

Figure 2-5 Block Diagram of the Expanded Scale Recording Thermometer

BASIC THEORY OF OPERATION

Figure 2-5 represents the basic Expanded Scale Recording Thermometer. The resistance of the thermistor temperature probe changes with a change in temperature and regulates the output of the Temperature Module. This produces a linear voltage representative of the temperature (i.e. 10 millivolts per degree regardless of range). The Potentiometric Amplifier serves as a preamplifier that converts any full scale input between 1 millivolt and 500 volts to a full scale output of 1 volt. Therefore, the output from the Temperature Module is expanded by the factor selected on the Amplifier's Range switches. For example, a temperature of 5°C (50 millivolts) will produce an output of 500 millivolts, if the Amplifier range is set at 100 millivolts per volt.

In order to utilize the full temperature range available, the DC Offset Module provides up to 15.1 divisions of offset to the Amplifier. That is, one division of offset will shift the Amplifier output one full span (1 volt). If in the above example, the temperature was 25°C (250 millivolts), the Amplifier output would be 2.5 volts. However, with two divisions of offset applied to the Amplifier, the output would be 500 millivolts.

The Chart Recorder requires an input of 1 volt for full-span pen deflection. Therefore, the output from the Amplifier must be regulated by its Range switch and the DC Offset Module. As a result, the Recorder indications must take into account range, offset, and pen deflection for all measurements other than a direct 1:1 ratio. Refer to the Specifications for a list of range vs recorder span.

*Compatible with all 700-Series YSI (Yellow Springs Instrument Company) probes.

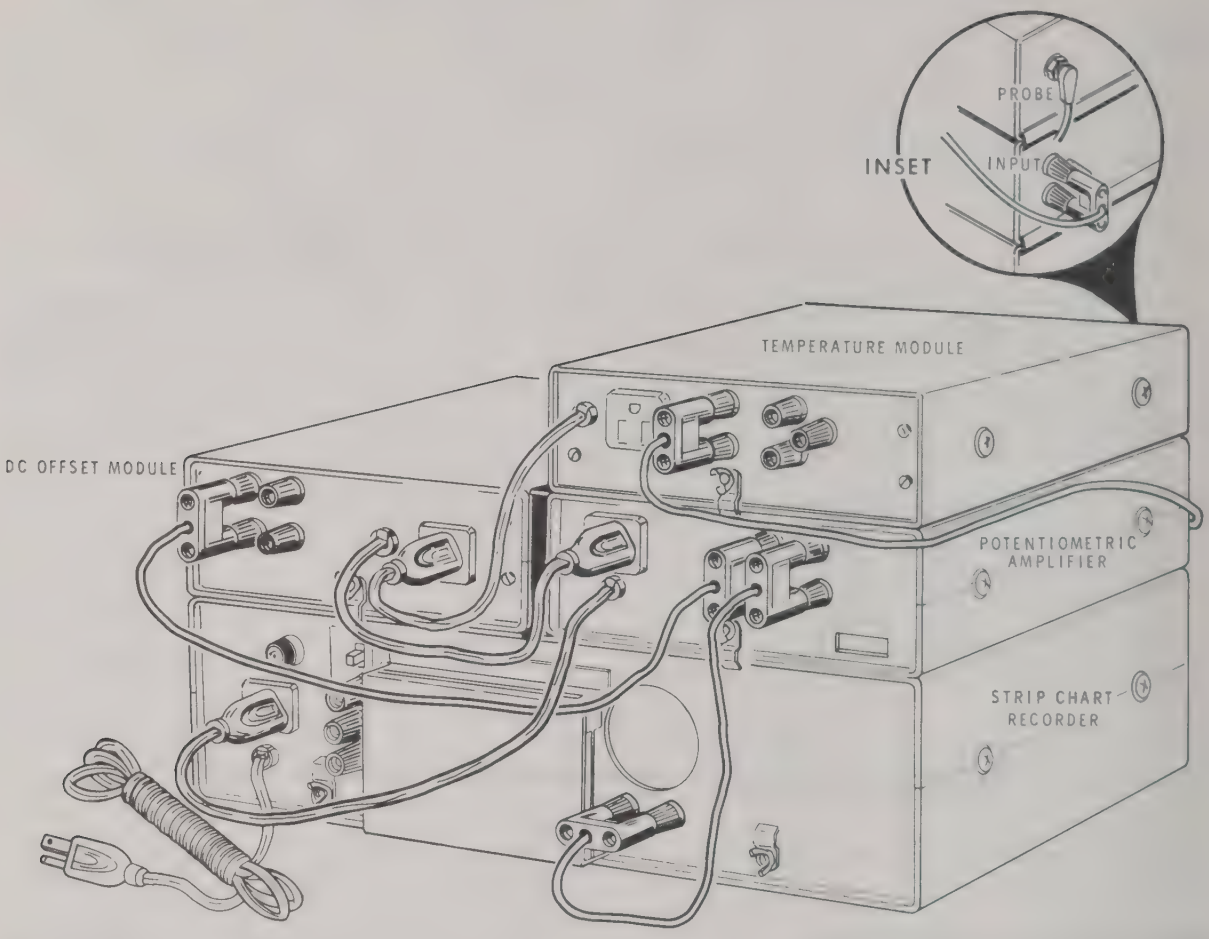

Figure 2-6

Rear panel interconnections required for operation as an expanded scale recording thermometer. The inset shows the front panel probe jack with a temperature probe installed and the Input to the Potentiometric Amplifier.

SETUP PROCEDURE

Set up the Programmable Strip Chart Recorder as described on Page 2-20. Then, refer to Figure 2-6 and mount the Temperature Module on the Amplifier and plug the line cord into the DC Offset Module. With the dual-banana cable, interconnect the Temperature Module Output and the Amplifier Input. Plug the temperature probe into the front panel jack of the Temperature Module.

Switch all four modules ON and depress the Temperature Module's Zero pushbutton. (Make sure the DC Offset Module controls are set at zero.) Adjust the Amplifier for the required chart span (refer to the specifications for usable temperature range per span). Select the desired chart speed, then depress the Recorder's Servo, Pen, and Chart push-buttons. Adjust the Recorder Zero control to position the pen at the desired reference or zero temperature point. Switch the Temperature Module to the required range and adjust the DC Offset Module for the necessary Amplifier offset. The system is ready for operation.

SPECIFICATIONS

Temperature Module Setting	Amplifier Range Setting	Chart Recorder Span	Resolution	Usable Range	Accuracy	Precision
–5°C to 45°C	10 mV/V	1°C	0.0025°C	–5°C to 16.1°C	±0.3°C	±.07° for ±5% line variations, ±5%/°C ambient chang <80% relative humidity, over a 1 week period
–5°C to 45°C	20 mV/V	2°C	0.005°C	–5°C to 32.2°C	±0.3°C	
–5°C to 45°C	50 mV/V	5°C	0.0125°C	–5°C to 45°C	±0.3°C	
–5°C to 45°C	100 mV/V	10°C	0.025°C	–5°C to 45°C	±0.3°C	
–30°C to 50°C	10 mV/V	1°C	0.0025°C	–16.1°C to 16.1°C	±0.35°C	
–30°C to 50°C	100 mV/V	10°C	0.025°C	–30°C to 50°C	±0.4°C	
0°C to 100°C	10 mV/V	1°C	0.0025°C	0°C to 16.1°C	±0.35°C	
0°C to 100°C	100 mV/V	10°C	0.025°C	0°C to 100°C	±0.4°C	

Input Probe:

- Type . . . . . SU-200-TA, SU-200-TB, SU-200-TC, and all YSI 700-Series probes.
- Dynamic Range . . . . . –30°C to 100°C.
- Interchangeability . . . . . ±0.15°C.

Linearity*:

- –5°C to 45°C . . . . . ±0.1°C (module calibrated at this range).
- –30°C to 50°C . . . . . ±0.25°C.
- 0°C to 100°C . . . . . ±0.3°C.
- 32°F to 200°F . . . . . ±0.7°F

Time Constant . . . . . Refer to specifications for individual probe.

Maximum Instrument Calibration Error . . . . . ±0.1°C or ±0.3°F for uncalibrated ranges.

Maximum Zero Set Shift Between Ranges . . . . . ±0.1°C or ±0.4°F for uncalibrated ranges.

Line Stability . . . . . 0.001°C/volt.

Offset:

Range	0 to 15.1 units, positive or negative polarity, in 1-unit or 0.1-unit steps.
Accuracy	Better than 0.1% of setting.
Zener Reference Supply	0.002%/°C, temperature compensated.
Output	1 unit = 0.5 volts.

Recorder:

Span	10 inches, calibrated 0-1 volt full scale.
Slidewire Linearity	0.1%.
Slewing Speed	20 inches/second.
Dead Zone	<0.1% of full scale.
Chart Speeds	Twenty-three speeds, selected by 6 pushbuttons: 2, 5, or 10 seconds per inch. Multiplier pushbuttons: x3, x10, and x60 may be used singly or in any combination.
Instrument Operating Temperature	10°C to 40°C ambient.
Power Requirements	105-125 Vac, 50/60 Hz, 59 watts maximum. (Can be rewired for 210-250 volt operation.)
Overall Dimensions	17-5/8" wide, 11-3/4" high, and 13-1/8" deep with writing panel in 45 degrees position.

FEATURES

Auxiliary Inputs:

External Chart Drive	EXT-INT switch, when in the EXT position, enables the chart drive to be synchronized with an external signal source. Refer to the EU-205-11 Manual for signal requirements.
Remote Servo Control	Connection of demodulator output to circuit ground (COM) with stop servo. NOTE: Up to ±4 volts at <1 mA may be applied to the grounding device.
Remote Pen Lift	Connection to chassis ground will lift pen. NOTE: Up to 0.7 volts at <15 mA may be applied to the grounding device.

*Remote Chart Control	Connection to chassis ground will stop chart. NOTE: Up to 5 volts at <40 mA may be applied to grounding device.
Pen Motor External Drive	Enables pen motor to be driven by external source. Requires 20 mV to start pen motion, and 100 mV for full speed operation. Input impedance 10 kΩ.

Auxiliary Outputs:

Slidewire	Enables slidewire to be connected to modules such as the EU-200-81 Servo Amplifier Patch Module.
Chart Drive Output	Enables external equipment (TTL compatible) to be synchronized to chart drive.
Calibrated Reference Supply	Both (+) and (—) sides of the floating reference supply are available. May be used as a reference source for such modules as the EU-200-81.
Zero Control	Enables the control to be used in external modules.
Servo "ON" signal	Chassis ground potential when Servo pushbutton is pressed in.
Chart "ON" signal	Chassis ground potential when Chart pushbutton is pressed in.
Null Signal Out	Minimum voltage (output) when pen reaches null point.

MULTIPLE CHANNEL RECORDING THERMOMETER

Many laboratory and manufacturing operations require that multiple thermal media receive constant recorded observation of temperature change. This is easily accomplished with the addition of a multiplexer system and the necessary temperature probes to a recording thermometer. The basic Multiple Channel Recording Thermometer consists of a Temperature Module, Multiplexer, Strip Chart Recorder, and up to four temperature probes*. It will accommodate up to four individual channels of data with the option of expanding to an unlimited number of channels. (Each additional Multiplexer added to the system will accomodate four temperature probes.) However, this instrumental versatility does not affect the high precision and stability obtained by the Recording Thermometer.

Because of the fully programmable nature of the Chart Recorder, each channel of data can be sequentially sampled and recorded during clearly defined time periods. This sampling rate can be varied between 1 and 20 seconds per sample with a self-contained programmer or up to 5 samples per second can be observed with a TTL compatible external programmer (see Specifications for complete signal parameters). In addition, pen-blanking between channels, TTL compatible binary-coded channel identification, and Channel 1 (Events) ON data is provided.

*Compatible with all 700-series YSI (Yellow Springs Instrument Company) probes.

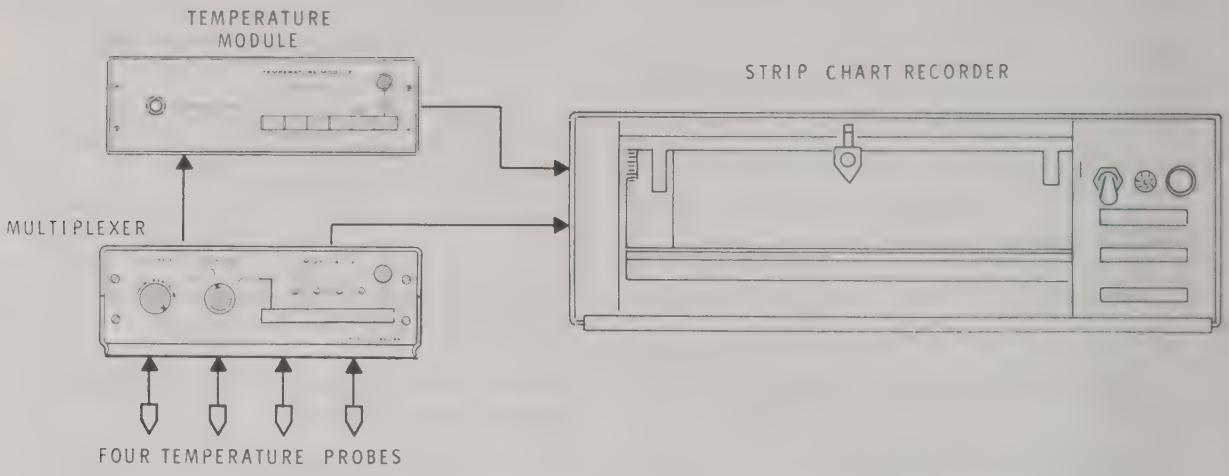

Figure 2-7 Block Diagram of Multiple Channel Recording Thermometer

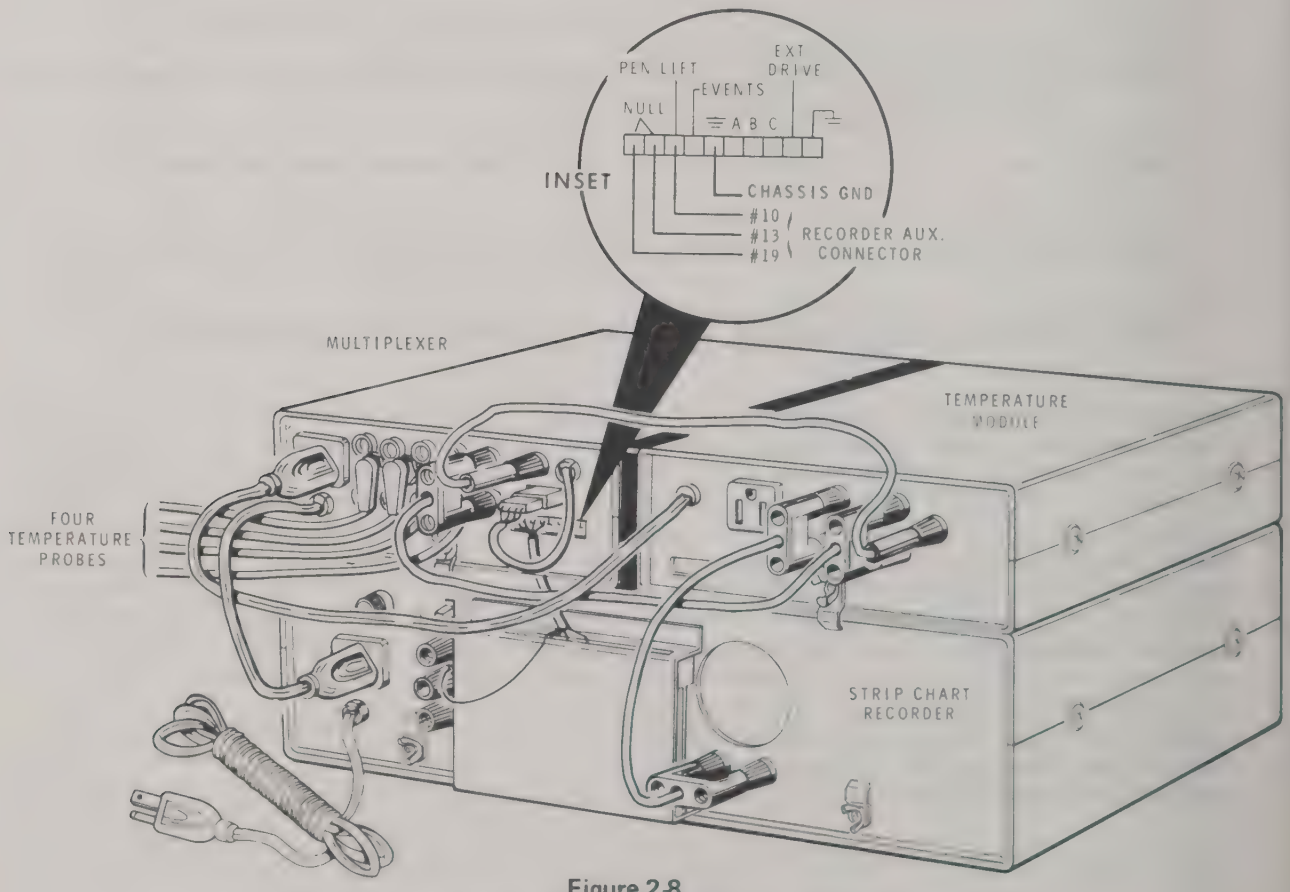

Figure 2-8

Rear panel interconnections required for operation as a multiple channel recording thermometer. The inset shows the auxiliary wire connections required for automatic pen control.

BASIC THEORY OF OPERATION

Figure 2-7 represents the basic Multiple Channel Recording Thermometer. Four thermistor temperature probes are connected to the four channels of the Multiplexer. Each probe is sequentially sampled by means of electronically-programmed reed relays. As each channel is enabled, the data obtained is coupled directly to the Temperature Module. The resistance of a thermistor temperature probe changes with a change in temperature and regulates the output of the Temperature Module. This produces a linear voltage representative of the temperature (i.e. 10 millivolts per degree regardless of range selected) which is coupled to the Chart Recorder and displayed.

In order to observe individual temperature indications, the Recorder pen is blanked between sample periods. This is accomplished through direct control of the Recorder by the Multiplexer.

SETUP PROCEDURE

Refer to Figure 2-8 and mount the Temperature Module and Multiplexer on the Recorder as described in Section 3 of this Manual. Plug the Temperature Module line cord into the Multiplexer power receptacle and plug the Multiplexer line cord into the Recorder's (switched) power receptacle. The Recorder power switch is now the Master power switch. Connect the Multiplexer Output to the Temperature Module rear panel Probe Input with the dual-banana cable (red and black binding posts) and the single-banana cable (white binding posts) supplied with the Temperature Module. Connect the Temperature Module Output to the Input of the Recorder with the Multiplexer's dual-banana cable. The five-wire cable provided with the Multiplexer is connected between the Multiplexer Auxiliary Connector and the Recorder Auxiliary Connector and Chassis Ground. Refer to the Inset illustration in Figure 2-8. This cable serves as a control interface to enable the Recorder pen during each window of the Multiplex scan. Connect the temperature probes to the Multiplexer Inputs (phone-type jacks).

Switch all three modules ON. Hereafter, only the Recorder power switch need be operated. Enable the Multiplexer channels to be scanned and select the Scan Mode. If the Auto Mode is used, adjust the Auto Rate control for the desired sampling rate. If the External Mode is selected, a TTL level signal must be connected to the Auxiliary Connector External and Ground positions. Depress the Zero Set pushbutton on the Temperature Module and the Servo and Pen pushbuttons on the Recorder. Depending on the temperature range to be observed, adjust the Recorder Zero control to position the pen at the desired reference or zero temperature point. (Temperature output is 10 millivolts per degree; therefore, the chart span is 100 degrees.) If the Fahrenheit range is selected, the full range cannot be observed since it would require a span of 180 degrees or 1800 millivolts.

Select the desired Chart Speed and temperature range. Depress the Chart pushbutton and mark the chart for future channel I.D. reference.

When two or more Multiplexers are used, only minor modifications to the basic System are required. Each Multiplexer is connected to the next with the Cascade cable and chassis connector on the rear panel. The final unit that utilizes the chassis connector only is the Master Multiplexer. Recorder pen control and the scan program are derived from the Master. The remaining Multiplexers in the String are switched to the Slave Mode. Connect the Outputs of the Slave units in parallel with the Master Output. Plug the temperature probes into the Multiplexer Inputs and enable these inputs with the Channel Selector pushbuttons. The remaining operation is unchanged.

SPECIFICATIONS

Stability:

Temperature	0.01°C/°C ambient.
Line Voltage	0.001°C/volt.
Precision	±0.13°C for ±5% line variation, ±5°C ambient, <80% relative humidity, over a one week period. (This specification does not allow for dimentional change of chart paper due to relative humidity.)
Range	100° full span.

Input Probe:	
Type	SU-200-TA, SU-200-TB, SU-200-TC, and all YSI 700-Series probes.
Dynamic Range	–30°C to 100°C.
Interchangeability	±0.15°C.
Linearity*:	
–5°C to 45°C	±0.17°C (module calibrated on this range).
–30°C to 50°C	±0.29°C.
0°C to 100°C	±0.35°C.
32°F to 200°F	±0.72°F.
Time Constant	Refer to Specifications for individual probe.
Maximum Calibration Error Between Ranges	±0.1°C or ±0.3°F for uncalibrated ranges.
Maximum Zero Shift Between Ranges	0.1°C or 0.4°F for uncalibrated ranges.
Internal Programmer:	
Rate	Variable 1 to 0.05 samples per second.
Time Jitter	≤5%, typical.
External Programmer Input:	
Signal	TTL compatible, 5 samples per second maximum. (Logic 0 ≤0.4 volts, Logic 1 ≥2.4 volts but ≤5.5 volts.)
Maximum Rise Time	1 volt/sec.
Minimum Pulse Width	100 ns.
Aperture Time Error	≤1 ms referenced to the channel ID signal at the rear panel connector.
Pen Lift Output	TTL level 0 to lift recorder pen when channels switch.
Events Output	TTL level 1 indicates channel 1 operation.
Channel I.D. Signal (A, B, C Output)	TTL level, BCD information.

*Refer to Probe Curves in the Temperature Module Manual.

Recorder:

Span	10 inches, calibrated 0-1 volt full scale.
Slidewire Linearity	0.1%.
Slewing Speed	20 inches/second.
Dead Zone	<0.1% of full scale.
Chart Speeds	Twenty-three speeds, selected by 6 pushbuttons: 2, 5, or 10 seconds per inch. Multiplier pushbuttons: x3, x10, and x60 may be used singly or in any combination.
Instrument Operating Temperature	10°C to 40°C ambient.
Power Requirements	105-125 Vac, 50/60 Hz, 54 watts maximum. (Can be rewired for 210-250 volt operation.)
Overall Dimensions	17-5/8" wide, 11-3/4" high, and 13-1/8" deep with writing panel in 45 degrees position.

FEATURES

Auxiliary Inputs:

External Chart Drive	EXT-INT switch, when in the EXT position, enables the chart drive to be synchronized with an external signal source. Refer to the EU-205-11 Manual for signal requirements.
Remote Servo Control	Connection of demodulator output to circuit ground (COM) with stop servo. NOTE: Up to ±4 volts at <1 mA may be applied to the grounding device.
Remote Pen Lift	Connection to chassis ground will lift pen. NOTE: Up to 0.7 volts at <15 mA may be applied to the grounding device.
Remote Chart Control	Connection to chassis ground will stop chart. NOTE: Up to 5 volts at <40 mA may be applied to grounding device.
Pen Motor External Drive	Enables pen motor to be driven by external source. Requires 20 mV to start pen motion, and 100 mV for full speed operation. Input impedance 10 kΩ.

Auxiliary Outputs:

Slidewire	Enables slidewire to be connected to modules such as the EU-200-81 Servo Amplifier Patch Module.
Chart Drive Output	Enables external equipment (TTL compatible) to be synchronized to chart drive.
Calibrated Reference Supply	Both (+) and (—) sides of the floating reference supply are available. May be used as a reference source for such modules as the EU-200-81.
Zero Control	Enables the control to be used in external modules.
Servo "ON" signal	Chassis ground potential when Servo pushbutton is pressed in.
Chart "ON" signal	Chassis ground potential when Chart pushbutton is pressed in.
Null Signal Out	Minimum voltage (output) when pen reaches null point.

DIGITAL VOLTMETER

The Potentiometric Amplifier has microvolt sensitivity, high input impedance (potentiometric input), and very good noise rejection. Therefore, it is ideally suited for combination with the Digitizer/Indicator to produce a high precision, multiple-range digital microvoltmeter. Accuracy is better than ±0.3% of full scale on six switch-selected ranges from 1 millivolt to 100 volts. Automatic decimal point control from the Amplifier results in a direct voltage indication on the Digitizer; and since both modules are bi-polar, negative voltages are also indicated directly. (All voltage readings are direct, regardless of multiplier button depressed, i.e. X1.)

Four decades of 1-2-4-8 BCD plus an indication of 0 or 1 in the fifth decade are available at the rear of the digital panel meter to drive external devices (i.e. digital printer). In addition, a print command output is also provided to key external printing devices for BCD acceptance. All of these outputs are compatible with TTL or its equivalent. A connector is supplied with the Digitizer/Indicator which may be used to make an output cable to facilitate access to these outputs. For more detail, refer to the manual that accompanies the digital panel meter.

BASIC THEORY OF OPERATION

Figure 2-9 represents the basic Digital Voltmeter. The Amplifier operates as a true potentiometric amplifier that generates an output voltage representative of the input. An exact fraction of the output is compared with and maintained equal to the input signal. Alternate comparison of input signal and feedback voltage is accomplished by a photo chopper that acts as a single-pole double-throw switch. At balance, the current drawn from the signal source is negligible. Thus, the input impedance is commonly said to be infinite for the three millivolt ranges. The off-balance input impedance is high enough to provide ideal performance for a source resistance of 50 k ohms or less. For the three volt ranges, the input impedance is 10 megohms. The Digitizer/Indicator displays the output voltage from the Amplifier with a resolution of 0.001 for the 1 millivolt and 1 volt range, 0.01 for the 10 millivolt and 10 volt range, and 0.1 for the 100 millivolt and 100 volt range. Automatic decimal point control is provided by the Amplifier through the use of selected resistors. As previously mentioned, voltage data are supplied by the digital panel meter for all BCDTTL compatible peripheral devices.

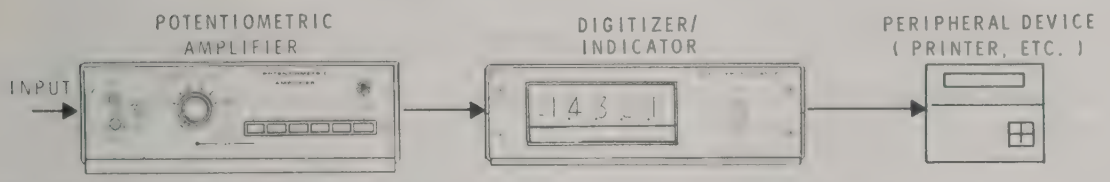

Figure 2-9 Block Diagram of the Digital Voltmeter

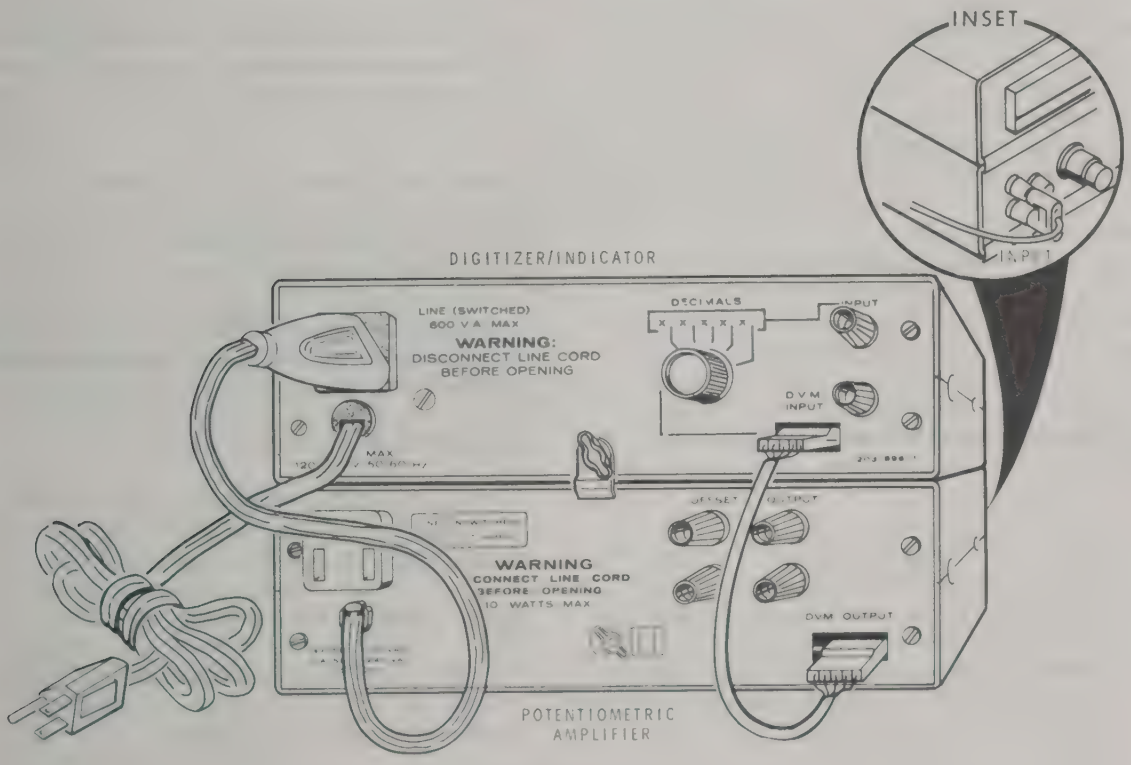

Figure 2-10

Rear panel interconnections required for operation as a digital voltmeter. The inset shows the front panel input jack with a dual banana cable connected.

SETUP PROCEDURE

Refer to Figure 2-10 and interconnect both modules with the DVM cable supplied with the Digitizer and switch the rear panel selector to the DVM INPUT position. Plug the Amplifier line cord into the Digitizer power receptacle. The Digitizer power switch is now the Master power control.

Connect the Digitizer line cord to a suitable power source. The signal is connected to the Input and Common binding posts on the Potentiometric Amplifier. Common is a floating circuit ground which may be shorted to the Ground (chassis ground) binding post to suppress some noise conditions. NOTE: A shorting bar must be placed between the Offset Input binding posts on the rear panel when no offset is applied, as in this application.

SPECIFICATIONS

Accuracy	0.25% of full scale, ±1 digit, ±5 μV @ 23°C.
Average Temperature Coefficient	100 ppm/°C.
Linearity	Better than 0.1%.
Frequency Response	≥2 Hz.
Noise Rejection (1 mV Scale)	Common mode at line frequency: 120 dB (input shorted). 60 dB at 100 ohm unbalance. DC common mode: 160 dB. Normal mode rejection: 40 dB.
Type Input	Potentiometric floating on 1 mV to 100 mV.
Maximum Voltage Input	On 1 mV to 100 mV ranges: 70 volts. On 1 V to 100 V ranges: 700 volts.
Input Impedance	True potentiometric "infinite" at balance, approximately 500 kΩ off null on 1 mV to 100 mV ranges. 10 MΩ on 1 V to 100 V ranges.
Recommended Source Impedance	50 kΩ maximum on millivolt ranges.
Input Ranges:	
1 mV	1.000 mV with overrange to 10.000 mV.
10 mV	10.00 mV with overrange to 100.00 mV.
100 mV	100.0 mV with overrange to 1000.0 mV.
1 V	1.000 V with overrange to 10.000 V.
10 V	10.00 V with overrange to 100.00 V.
100 V	100.0 V with overrange to 700.0 V.
BCD Outputs	Available at rear of Digital Panel Meter (DPM), see Weston 1294 Manual for details.
Operating Temperature	10°C to 40°C ambient.
Power Requirements	105-130 volts, 50/60 Hz, 20 watts maximum. (Can be rewired for 210-260 volt operation.)
Dimensions	8-3/4" wide, 11-1/4" deep, 6-1/8" high.

PROGRAMMABLE STRIP CHART RECORDER

A versatile, high performance, Programmable Strip Chart Recorder is produced when a Potentiometric Amplifier and DC Offset Module are integrated with a multi-speed Strip Chart Recorder (instrument available as model EU-205B). Because of its potentiometric input, the input impedance is extremely high at balance. Therefore, the input voltage from sources of relatively high resistance can be measured without significant loading. Input voltage spans range from 1 millivolt to 500 volts in 18 calibrated ranges and for observation of small voltage changes superimposed on larger voltages, 15.1 calibrated units of offset (zero suppress) are provided.

The recorder mainframe is a Y-T plotter where the time T axis is controlled by a stepper motor that moves the chart paper in small precise increments (less than pen width). This method allows a large number of highly-accurate switch-selected rates without any gear changes. It also allows easy synchronization of chart movement with external devices such as monochromator wavelength drives, incremental solution delivery devices, etc.

Along with its high performance, microvolt recording capability, this instrument is fully programmable. A readily accessible connector block on the rear panel provides the following inputs and outputs: Inputs—Chart Drive, Servo, Pen Lift, Chart Control, and Pen Motor. Outputs-Slidewire, TTL compatible Chart Drive, Reference Supply, Zero Control, Chart and Servo ON, and Servo Null Signals. All functions are controlled by logic circuits or contact closures.

BASIC THEORY OF OPERATION

Figure 2-11 represents the Programmable Strip Chart Recorder. The Amplifier operates as a true potentiometric amplifier that generates an output voltage. An exact fraction of the output is compared with and maintained equal to the input signal. Alternate comparison of input signal and feedback voltage is accomplished by a photo chopper that acts as a single-pole double-throw switch. At balance, the current drawn from the signal source is negligible. Thus, the input impedance is commonly said to be infinite for the three millivolt ranges. The off-balance input impedance is high enough to provide ideal performance for a source resistance of 50 kilohms or less. For the three volt ranges, the input impedance is 10 megohms.

The Offset Module provides 15.1 calibrated units of suppress in 14 full scale steps and 1.1 units in 11 one-tenth scale steps. As a result, small changes of input voltage superimposed on a large average input voltage can be spread out over the full width of the chart. For example, with the Offset Module set at 14 units of suppress and the Amplifier set on the 1 millivolt range, changes of input voltage between 14 and 15 millivolts would be spread across the entire chart width.

Therefore an input voltage is conditioned by the Amplifier to produce an equivalent deflection on the Recorder (i.e. 1 millivolt input on the 1 millivolt range produces a 1 volt signal to the Recorder for full span deflection). Where offset is required, it is applied to the Amplifier's summing amplifier to produce the necessary suppress on the output.

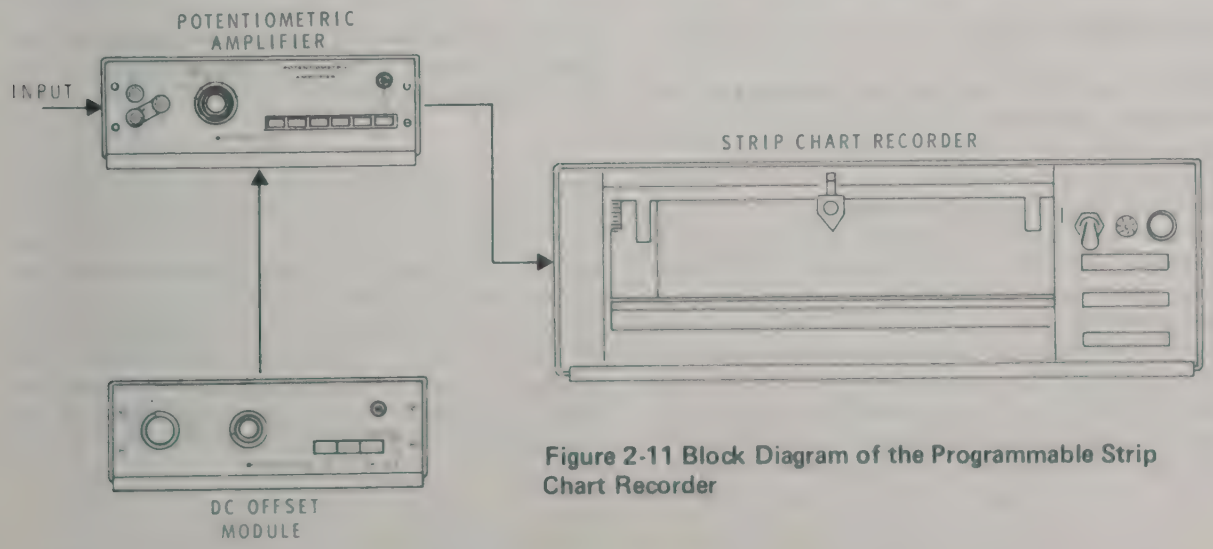

Figure 2-11 Block Diagram of the Programmable Strip Chart Recorder

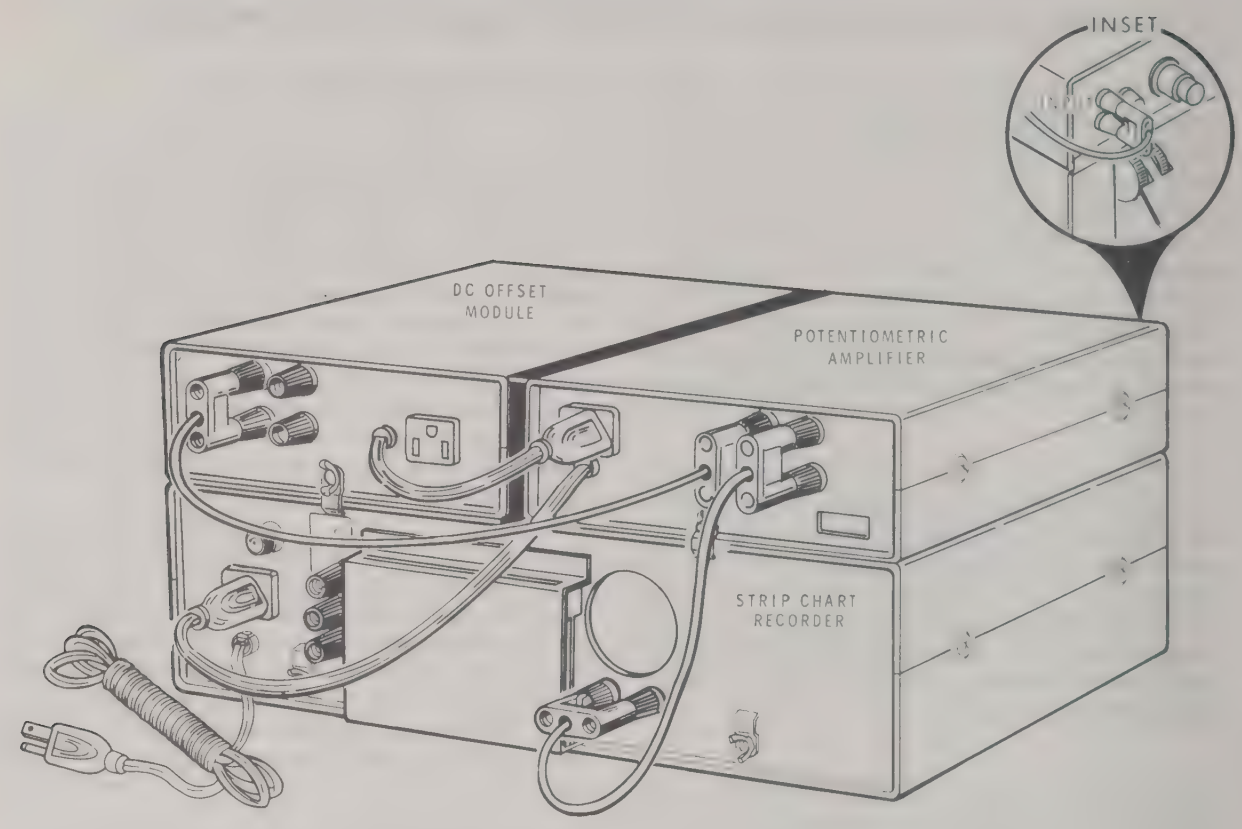

Figure 2-12

Rear panel interconnections required for operation as a programmable strip chart recorder. The inset shows the front panel input jack with a dual banana cable connected.

SETUP PROCEDURE

Refer to Figure 2-12 and mount the Amplifier and Offset Modules on the Recorder as described in Section 3 of this Manual. (Place the Amplifier on the left side of the Recorder, so that the input cable will not interfere with pen operation.) Plug the DC Offset Module line cord into the Amplifier and plug the Amplifier line cord into the Recorder's (switched) power receptacle. The Recorder power switch is now the Master power switch. Remove the shorting bar from the Amplifier's Offset Input and connect this Input to the Output of the DC Offset Module with the dual-banana cable from the Module. When the DC Offset Module is not in use, it can be turned OFF. This will short its Output jacks. Connect the Output of the Amplifier to the Input of the Recorder with the dual-banana cable from the Amplifier. Connect the signal source to the Input and Common of the Amplifier.

Select the desired chart span with the Amplifier's Range and Multiplier switches. If offset is required, adjust the DC Offset Module. Select the chart speed and turn all three modules ON. Depress the Servo, Pen, and Chart push-buttons. Press the Amplifier's Zero button and adjust the pen for a zero indication of the chart. The system is ready for operation. NOTE: As previously mentioned, all of the Recorder functions can be externally controlled through the Auxiliary Connector on the rear panel. Refer to the Recorder Manual for more information.

SPECIFICATIONS

Input Voltage (Full Scale)	1 mV to 500 V in 18 ranges.
Accuracy	±0.2% of full scale.
Linearity	0.1%.
Line Stability	0.001%/volt.
Preamplifier:	
Frequency Response	≥2 Hz.
Noise Rejection (1 mV Scale)	Common mode at line frequency: 120 dB (input shorted). 60 dB at 100 Ω unbalance. DC common mode: 160 dB. Normal mode rejection: 40 dB.
Type Input	Potentiometric floating on 1 mV to 100 mV.
Maximum Voltage Input	On 1 mV to 100 mV ranges: 70 V. On 1 V to 100 V ranges: 700 V.
Input Impedance	True potentiometric "infinite" at balance, approximately 500 kΩ off null on the 1 mV to 100 mV ranges. 10 MΩ on the 1 V to 100 V ranges.
Recommended Source Impedance	50 kΩ maximum on millivolt ranges.
Offset:	
Range	0 to 15.1 units, positive or negative polarity, in 1-unit or 0.1-unit steps.
Accuracy	Better than 0.1% of setting.
Zener Reference Supply	0.002%/°C, temperature compensated.
Output	1 unit = 0.5 V.
Recorder:	
Span	10 inches, calibrated 0-1 volt full scale.
Slidewire Linearity	0.1%.
Slewing Speed	20 inch/sec.
Dead Zone	<0.1% of full scale.
Chart Speeds	Twenty-three speeds, selected by 6 pushbuttons: 2, 5, or 10 seconds per inch. Multiplier pushbuttons: x3, x10, and x60 may be used singly or in any combination.

Instrument Operating Temperature	10°C to 40°C ambient.
Power Requirements	105-125 volts, 50/60 Hz, 60 watts maximum. (Can be rewired for 210-250 volt operation.)
Overall Dimensions	17-5/8" wide, 8-3/8" high, and 13-1/8" deep, with writing panel in 45 degree position.

FEATURES

Auxiliary Inputs:

External Chart Drive	EXT-INT switch, when in the EXT position, enables the chart drive to be synchronized with an external signal source. Refer to the EU-205-11 Manual for signal requirements.
Remote Servo Control	Connection of demodulator output to circuit ground (COM) with stop servo. NOTE: Up to ±4 volts at <1 mA may be applied to the grounding device.
Remote Pen Lift	Connection to chassis ground will lift pen. NOTE: Up to 0.7 volts at <15 mA may be applied to the grounding device.
Remote Chart Control	Connection to chassis ground will stop chart. NOTE: Up to 5 volts at <40 mA may be applied to grounding device.
Pen Motor External Drive	Enables pen motor to be driven by external source. Requires 20 mV to start pen motion, and 100 mV for full speed operation. Input impedance 10 kΩ.

Auxiliary Outputs:

Slidewire	Enables slidewire to be connected to modules such as the EU-200-81 Servo Amplifier Patch Module.
Chart Drive Output	Enables external equipment (TTL compatible) to be synchronized to chart drive.
Calibrated Reference Supply	Both (+) and (—) sides of the floating reference supply are available. May be used as a reference source for such modules as the EU-200-81.
Zero Control	Enables the control to be used in external modules.
Servo "ON" signal	Chassis ground potential when Servo pushbutton is pressed in.
Chart "ON" signal	Chassis ground potential when Chart pushbutton is pressed in.
Null Signal Out	Minimum voltage (output) when pen reaches null point.

DIGITAL pH/pIon METER

A pH/pIon Electrometer, Digitizer/Indicator, and a suitable ion selective electrode combine to produce a precise, high impedance, Digital pH/pIon Meter with 4-1/2 digit resolution. In addition, automatic temperature compensation (ATC) is provided as an option. A rear panel jack will accept any 700-series YSI (Yellow Springs Instrument Company) probe and a front panel switch selects the function.

Convenient front panel controls permit selection of Cation (pH), Anion, or Millivolt modes. A manual temperature control (when ATC is not used) allows direct readout of pX*, regardless of test solution temperature from 0°C to 100°C. Automatic pH slope control is provided, while precise calibration of the specific slope and intercept of the individual electrode is accomplished with separate controls on the front panel. Precise millivolt measurement from 0 to ±1999.9 millivolts is available with single switch selection. Automatic decimal point ranging is provided by the Electrometer.

Input connectors on the Electrometer accept the universally used electrode plug (Beckman-type) or BNC plug, for the test (ion-selective) electrode, and a pin or banana plug for the reference electrode. The BNC input connector is especially desirable for connecting voltage sources of high output impedance. There are also terminals on the rear panel for polarization of electrodes as required for the Karl Fisher Titration.

As an option, four decades of 1-2-4-8 BCD plus an indication of 0 or 1 in the fifth decade are available at the rear of the digital panel meter to drive external devices (i.e. digital printer). In addition, a print command output is also provided to key external printing devices for BCD information acceptance. All of these outputs are compatible with TTL or its equivalent. A connector is supplied with the Digitizer/Indicator which may be used to make an output cable for access to these outputs. For more detail, refer to the manual that accompanies the digital panel meter.

*pX refers to pH or pIon (= -log of ion activity).

BASIC THEORY OF OPERATION

Figure 2-13 represents the Digital pH/pIon Meter. An electrochemical cell (ion-sensitive electrode) produces a potential that is described by an equation of a straight line with slope. This line, the electrode response, dictates that for each value of pX there is a corresponding value of potential. To accommodate the particular response of each electrode a Standardize control and a Slope control are provided. The Standardize control shifts the instrument response laterally and the Slope control rotates the instrument response about the zero-crossing point (for pH, 7 pH). A separate Temperature control, which works independently of the Slope control, is used to correct the slope for changes in temperature. With these controls it is possible to bring the Electrometer's response into coincidence with the electrode. The Digitizer/Indicator displays the output voltage from the Electrometer with 0.001 pX (0.1 mV) resolution.

There are a small number of ion-selective electrodes that operate beyond the response conditioning capabilities of this instrument (e.g. greater than 10,000 MΩ resistance). In these instances, interpolation of the readout is required. For most ions for which there are suitable electrodes, the readout is in terms of activity. Thus, these pIon values must be converted by the equation $pIon = -\log_{10} X_a$, where X_a is ion activity.

Figure 2-13 Block Diagram of the Digital pH/pIon Meter

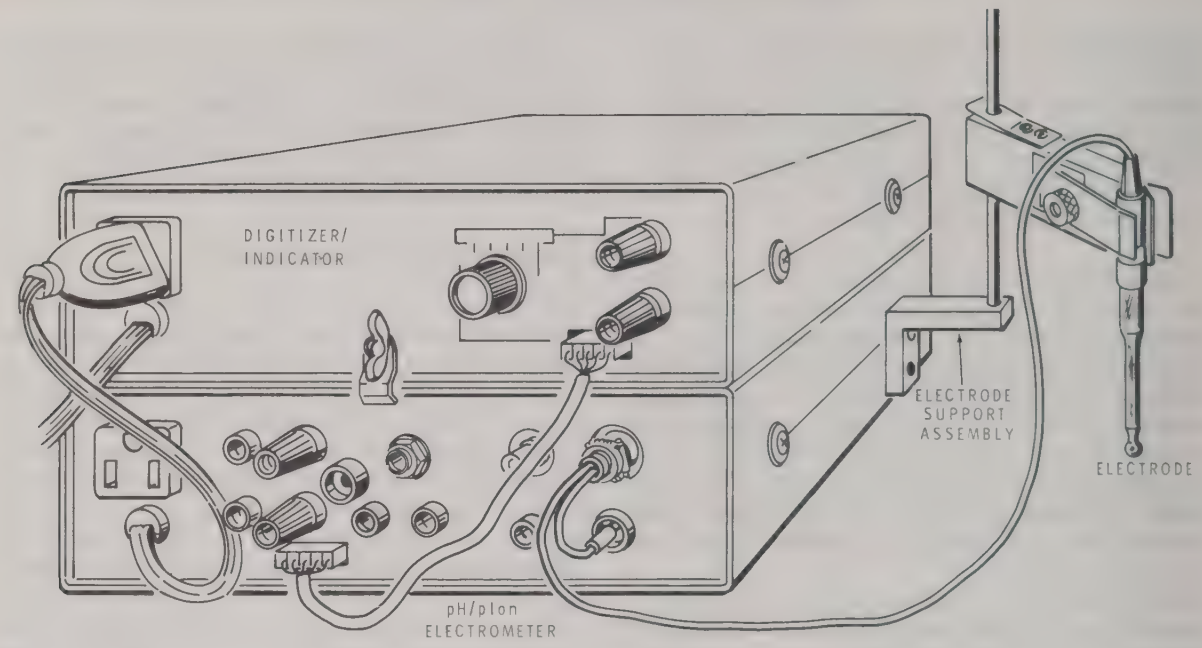

Figure 2-14

Rear panel interconnections required for operation as a digital pH meter.

SETUP PROCEDURES

Refer to Figure 2-14 and interconnect both modules with the DVM cable supplied with the Digitizer and switch the rear panel selector to the DVM INPUT position. Plug the Electrometer line cord into the Digitizer power receptacle. The Digitizer power switch is now the Master power control. Connect the Digitizer line cord to a suitable power source. Connect the test electrode to either the BNC or Beckman jack and the reference electrode to the pin or banana jack. The pin and banana jacks, and the shells of the BNC and Beckman connectors are common internally. If a temperature probe is used for automatic temperature compensation (ATC) connect it to the phone-type jack on the rear panel.

NOTE: All ion-selective electrodes require special handling prior to, during, and after use. Refer to the instructions on "Care and Feeding" that accompany the electrode.

Switch the Electrometer and Digitizer ON. Switch the Anion-Cation control to Cation (pH). If a temperature probe is used, depress the ATC button; the lamp over the button will light. (CAUTION: Be sure that the probe is chemically inert to the solution under test.) If a temperature probe is not used, adjust the Temperature control to the solution's temperature. (The ATC button must be released.) Switch the Range/Volt Out switch to 10 pX and the Slope select to Theoretical (pH). The Slope control is switched out of the circuit by the Slope select. Place the electrode in a 7 pH standard buffer solution and adjust the Standardize control for a 7.000 pH indication. NOTE: It is important to have the buffer and test solution at the same temperature. In applications other than pH determination, the Slope select switch is placed in the Slope position. Use a two-point calibration procedure with suitable buffer solutions to adjust the Slope and Intercept for the individual ion under test.

Because it is highly desirable to mount this instrument on a gimbal bracket, provision has been made to attach the electrode support assembly to one leg of the gimbal bracket. This allows the electrode to remain vertical when the display is tilted.

SPECIFICATIONS

NOTE: These specifications are listed in terms of pH or mV. Specifications for pIon determination are dependent on the electrode used and the ion under investigation. In some instances, interpolation of the readout is required.

Range	0-14 pH or 0 to ±1.9999 V full scale.
Maximum Input	10 V.
Input Impedance	$>10^{12}$ Ω, at 25°C.
Input Bias Current	0.5 pA, at 25°C.
Temperature Coefficient	0.002 pH/°C.
Resolution	0.001 pH, 0.1 mV.
Accuracy:	
pH	±0.002 pH, when the sample is within 3 pH units of the Standardization point.
mV	±0.2%, ±1 digit.
Line Stability	0.0001 pH/V.
Operating Temperature	10°C to 40°C ambient.
Power Requirements	105-130 volts, 50/60 Hz, 16 watts maximum. (Can be rewired for 210-260 volt operation).
Dimensions	8-3/4" wide, 11-1/8" deep, 6-1/8" high.

FEATURES

BCD Outputs	Available at rear of Digital Panel Meter. (DPM), see Weston 1294 Manual for details.
Polarization	10 μA current for Karl Fisher Titration.
Automatic Decimal Point Selection	Provided by Electrometer. Binary coded, TTL compatible decimal information provided on Digitizer decoder circuit board connector (inside cabinet).
Versatile Electrode Holder	Accommodates test and reference electrodes or a combination electrode.
Front Panel Controls:	
Temperature Compensation	Manual or Automatic, 0°C to 100°C.
Standardize	8 turn, ±100 mV range.
Slope Control	20 mV to 115 mV/100 mV out.
Slope Switch	Theoretical pH or manual Slope control.
Zero Set	Shorts Recorder Out terminals.
Anion–Cation (pH)	Selects polarity of slope.

EXPANDED SCALE RECORDING pH/pIon METER

High resolution and precision make the Expanded Scale Recording pH/pIon Meter extremely useful in research applications. This instrument is comprised of a pH/pIon Electrometer, DC Offset Module, Strip Chart Recorder, and a suitable ion selective electrode. Convenient front panel controls permit selection of Cation (pH), Anion, or Millivolt modes with resolution to 1 pX* (or 100 mV) full span. The other range positions are 2 pX, 5 pX, and 10 pX full span. Regardless of the range selected, each unit of offset applied to the Electrometer will shift the Recorder display 1 pX (or 100 mV). In addition, automatic temperature compensation (ATC) is provided as an option. A rear panel jack on the Electrometer will accept any 700-series YSI (Yellow Springs Instrument Company) probe.

A manual temperature control (when ATC is not used) allows direct display of pX, regardless of test solution temperature, from 0°C to 100°C. Automatic pH slope control is provided, while precise calibration of the specific slope and intercept of the individual electrode is accomplished with separate controls on the front panel.

Input connectors on the Electrometer accept the universally-used electrode plug (Beckman-type) or BNC plug for the test (ion-selective) electrode, and a pin or banana plug for the reference electrode. The BNC input connector is especially desirable for connecting voltage sources of high output impedance. There are also terminals on the rear panel for polarization of electrodes as required for the Karl Fisher Titration.

Along with its high performance recording capability, the Chart Recorder is fully programmable. A readily accessible connector block on the rear panel provides the following inputs and outputs: Inputs—Chart Drive, Servo, Pen Lift, Chart Control, and Pen Motor. Outputs—Slidewire, TTL-compatible Chart Drive, Reference Supply, Zero Control, Chart and Servo ON, and Servo Null Signals. All functions are controlled by logic circuits or contact closures.

BASIC THEORY OF OPERATION

Figure 2-15 represents the Expanded Scale Recording pH/pIon Meter. An electrochemical cell (ion-sensitive electrode) produces a potential that is described by an equation of a straight line with slope. This line, the electrode response, dictates that for each value of pX there is a corresponding value of potential. To accommodate the particular response of each electrode a Standardize control and a Slope control are provided. The Standardize control shifts the instrument response laterally and the Slope control rotates the instrument response about the zero-crossing point (for pH, 7 pH). A separate Temperature control, which works independently of the Slope control, is used to correct the slope for changes in temperature. With these controls it is possible to bring the Electrometer's response into coincidence with the electrode.

The potential produced by the electrode is expanded and ranged to produce a full scale output of 1 volt. Using pH measurement as an example, a 1 pH indication on the 2 pX Range would cause the recorder pen to deflect half scale. In order to utilize the full pH range available, the DC Offset Module provides up to 15.1 pX units of offset (zero suppress). That is, one division of offset will shift the Electrometer output 1 pX unit, regardless of output range. If in the above example, the pH was 2.5, the recorder pen would deflect off-scale. However, with two units of offset applied to the Electrometer, the recorder pen will deflect 1/4-scale for an indication of 2.5 pH.

There are a small number of ion-selective electrodes that operate beyond the response-conditioning capabilities of instrument (i.e. greater than 10,000 MΩ resistance). In these instances, interpolation of the output is required. For most ions for which there are suitable electrodes, the readout required is in terms of activity. Thus, these pIon values must be converted by the equation $pIon = -\log_{10} X_a$, where X_a is ion activity.

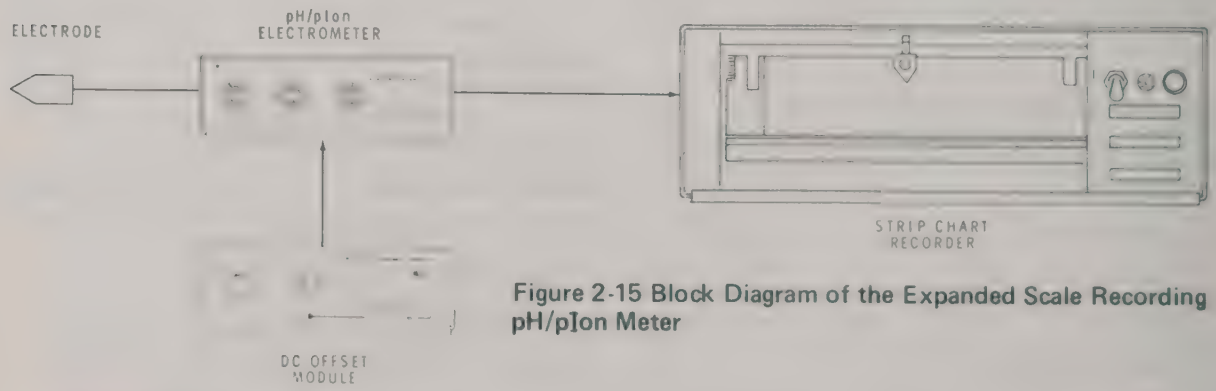

Figure 2-15 Block Diagram of the Expanded Scale Recording pH/pIon Meter

*pX refers to pH or pIon (= -log of ion activity).

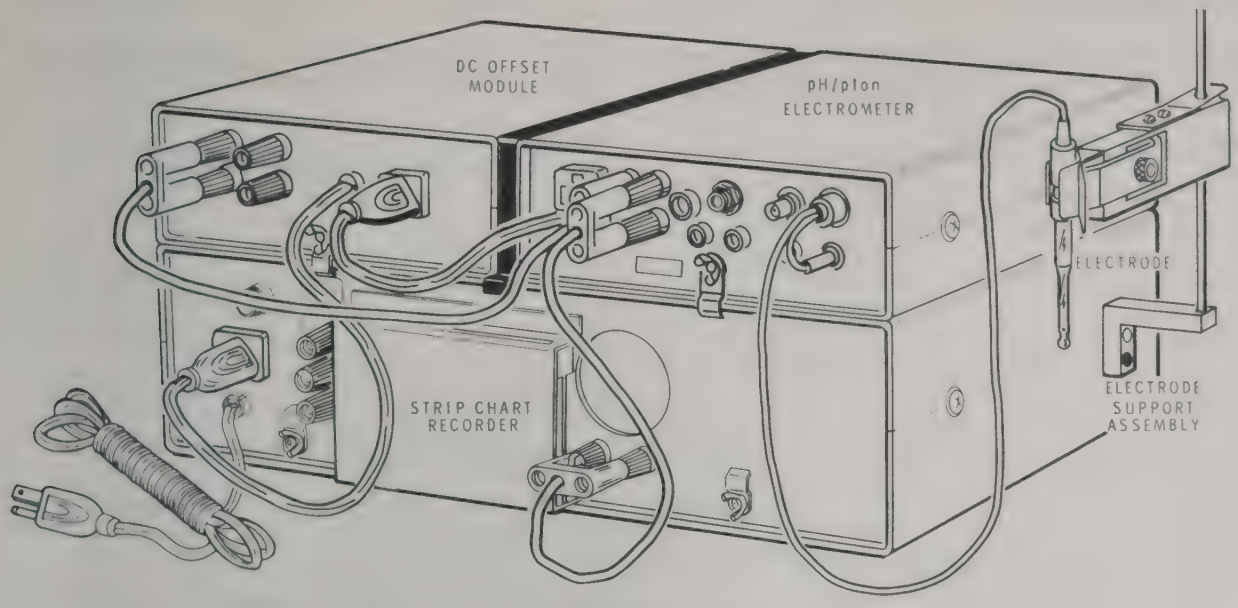

Figure 2-16

Rear panel interconnections required for operation as an expanded scale recording pH meter.

SETUP PROCEDURE

Refer to Figure 2-16 and mount the Electrometer and Offset modules on the Recorder as described in Section 3 of this Manual. Plug the Electrometer line cord into the Offset Module and plug the Offset Module line cord into the Recorder's (switched) power receptacle. The Recorder power switch is now the Master power switch. Connect the Output of the DC Offset Module to the Offset Input of the Electrometer with the dual-banana cable supplied with the Offset Module. Connect the Output of the Electrometer to the Input of the Recorder with the dual-banana cable supplied with the Electrometer. Connect the test electrode to either the BNC or Beckman jack and the reference electrode to the pin or banana jack. The pin and banana jacks, and the shells of the BNC and Beckman connector are common internally. If a temperature probe (YSI* 700-series only) is used for automatic temperature compensation (ATC) connect it to the phone-type jack on the rear panel.

NOTE: All ion-selective electrodes require special handling prior to, during, and after use. Refer to the instructions on "Care and Feeding" that accompany the electrode.

Switch the Electrometer, DC Offset Module, and Recorder ON. Switch the Anion-Cation control to Cation (pH). If a temperature probe is used, depress the ATC button; the lamp over the button will light. (CAUTION: Be sure that the probe is chemically inert to the solution under test.) If a temperature probe is not used, adjust the Temperature control to the solution's temperature. (The ATC button must be released.) Switch the Range/Volt Out switch to 10 pX and the Slope select to Theoretical (pH). The Slope control is switched out of the circuit by the Slope select. Depress the Zero Set pushbutton on the Electrometer, and the Servo and Pen pushbuttons on the Recorder. Adjust the Zero control for a pen deflection of zero. Release the Zero Set pushbutton and place the electrode in a 7 pH standard buffer solution. Adjust the Standardize control for a 7.00 pen deflection (7.00 pH). When precise measurements are required, the Electrometer slope should be adjusted to a standard buffer with a pH near that of the solution under test. Switch the Slope select to the Slope position, to activate the Slope control. NOTE: It is important to have the buffer and test solution at the same temperature.

Select the desired chart span with the Electrometer's Range switch (pX). Then, switch in the offset required to record the desired pH window. (One division of offset is equivalent to 1 pH of offset regardless of pX range.) Select the Chart Speed and depress the Chart pushbutton. Mark the chart for future I.D. reference.

*Yellow Springs Instrument Company

SPECIFICATIONS

NOTE: These specifications are listed in terms of pH or mV. Specifications for pIon determination are dependent on the electrode used and the ion under investigation. In some instances, interpolation of the indication is required.

Range	0-14 pH. 0 to ±10 volts, with a 1 volt dynamic range.
Maximum Input Voltage	10 volts.
Input Impedance	$>10^{12}$ Ω, at 25°C.
Input Bias Current	0.5 pA, at 25°C.
Drift	0.0015 pH/°C.
Maximum Resolution	0.0025 pH. 0.25 mV.
Accuracy:	
pH	±0.003 pH (assuming the pH sample is within 3 pH units of the Standardization point).
mV	±0.3% of reading.
Line Stability	0.0001 pH/V.
Offset:	
Range	0 to 15.1 units, positive or negative polarity, in 1-unit or 0.1-unit steps.
Accuracy	Better than 0.1% of setting. (Corresponds to 0.001 pH/pH unit suppressed).
Zener Reference Supply	0.002%/°C, temperature compensated.
Output	1 unit = 0.5 volts.
Recorder:	
Span	10 inches, calibrated 0-1 volt full scale.
Slidewire Linearity	0.1%.
Slewing Speed	20 inches/second.
Dead Zone	<0.1% of full scale.
Chart Speeds	Twenty-three speeds, selected by 6 pushbuttons: 2, 5, or 10 seconds per inch. Multiplier pushbuttons: x3, x10, and x60 may be used singly or in any combination.

Instrument Operating Temperature	10°C to 40°C ambient.
Power Requirements	105-125 Vac, 50/60 Hz, 51 watts maximum. (Can be rewired for 210-250 volt operation.)
Overall Dimensions	17-5/8" wide, 8-3/4" high, and 13-1/8" deep with writing panel in 45 degree position.

FEATURES

ELECTROMETER

Front Panel Controls:

Temperature Compensation	Manual or Automatic, 0°C to 100°C.
Standardize	8 turn, ±100 mV range.
Slope Control	20 mV to 115 mV/100 mV out.
Slope Switch	Theoretical pH or manual Slope control.
Zero set	Shorts Recorder Out terminals.
Anion–Cation (pH)	Selects polarity of slope.

Rear Panel Connectors:

Expanded Recorder Output	1 pH, 2 pH, 5 pH, 10 pH, 100 mV, 200 mV, 500 mV, and 1000 mV for 1 V out.
Inputs	Universal (Beckman-type) and BNC for glass or ion selective electrode. Pin and banana jacks for reference electrode.
DVM Output	100 mV/pH, 100 mV/100 mV, and decimal point (D.P.) control.
Polarization	10 μA current for Karl Fisher Titration.
Versatile Electrode Holder	Accommodates glass and reference electrodes or a combination electrode.

OFFSET MODULE

Switched Variable Gain Control	Allows for uncalibrated gain adjustment between 0.1-unit steps.
Polarity Switch	Selects negative or positive output.
DVM Monitor Output	Calibrated output for remote monitoring of the offset voltage: 1 unit = 0.1 volts.

CHART RECORDER

Auxiliary Inputs:

External Chart Drive	EXT-INT switch, when in the EXT position, enables the chart drive to be synchronized with an external signal source. Refer to the EU-205-11 Manual for signal requirements.
Remote Servo Control	Connection of demodulator output to circuit ground (COM) with stop servo. NOTE: Up to ±4 volts at <1 mA may be applied to the grounding device.
Remote Pen Lift	Connection to chassis ground will lift pen. NOTE: Up to 0.7 volts at <15 mA may be applied to the grounding device.
Remote Chart Control	Connection to chassis ground will stop chart. NOTE: Up to 5 volts at <40 mA may be applied to grounding device.
Pen Motor External Drive	Enables pen motor to be driven by external source. Requires 20 mV to start pen motion, and 100 mV for full speed operation. Input impedance 10 kΩ.

Auxiliary Outputs:

Slidewire	Enables slidewire to be connected to modules such as the EU-200-81 Servo Amplifier Patch Module.
Chart Drive Output	Enables external equipment (TTL compatible) to be synchronized to chart drive.
Calibrated Reference Supply	Both (+) and (–) sides of the floating reference supply are available. May be used as a reference source for such modules as the EU-200-81.
Zero Control	Enables the control to be used in external modules.
Servo "ON" signal	Chassis ground potential when Servo pushbutton is pressed in.
Chart "ON" signal	Chassis ground potential when Chart pushbutton is pressed in.
Null Signal Out	Minimum voltage (output) when pen reaches null point.

MULTIPLE CHANNEL pH/pIon RECORDER

The pX* of any number of media can be scanned and recorded with high resolution and precision by a Multiple Channel pH/pIon Recording System. Although, because of the very high impedance of an ion-selective electrode and the separate calibration required for each electrode, each channel will require an Electrometer and electrode. The system in this application consists of a Strip Chart Recorder, Multiplexer, three Electrometers and three ion-selective electrodes. (Each Multiplexer can accomodate up to four channels of data with the capability of cascading additional Multiplexers.) However, this instrumental versatility does not affect the high resolution and precision obtained by the Recording pH/pIon Meter.

Convenient front panel controls permit selection of Cation (pH), Anion, or Millivolt modes with resolution to 0.025 pX (or 2.5 mV). In addition, automatic temperature compensation (ATC) is provided as an option. A rear panel jack on each Electrometer will accept any 700-series YSI (Yellow Springs Instrument Company) probe. A manual temperature control (when ATC is not used) allows direct display of pX ragardless of test solution temperature, from 0°C to 100°C. Automatic pH slope control is provided. However, precise calibration to the specific slope and intercept of the individual electrode may be accomplished with separate controls on the front panel of each Electrometer.

*pX refers to pH or pIon (= -log of ion activity).

Input connectors on the Electrometer accept the universally-used electrode plug (Beckman-type) or BNC plug, for the test (ion-selective) electrode, and a pin or banana plug for the reference electrode. The BNC input connector is especially desirable for connecting voltage sources of high output impedance. There are also terminals on the rear panel for polarization of electrodes as required for the Karl Fisher Titration.

Because of the fully programmable nature of the Chart Recorder, each channel of data can be sequentially sampled and recorded during clearly defined time periods. This sampling rate can be varied between 1 and 20 seconds per sample with a self-contained programmer or up to 5 samples per second can be observed with a TTL compatible external programmer (see Specifications for complete signal parameters). In addition to pen-blanking between channels, TTL compatible binary-coded channel identification and Channel 1 (Events) ON data is provided.

BASIC THEORY OF OPERATION

Figure 2-17 represents the basic Multiple Channel Recording pH/pIon Meter. An electrochemical cell (ion-sensitive electrode) produces a potential that is described by an equation of a straight line with slope. This line, the electrode response, dictates that for each value of pX there is a corresponding value of potential. To accommodate the particular response of each electrode a Standardize control and a Slope control are provided. The Standardize control shifts the instrument response laterally and the Slope control rotates the instrument response about the zero-crossing point (for pH, 7 pH). A separate Temperature control, which works independently of the Slope control, is used to correct the slope for changes in temperature. With these controls it is possible to bring the Electrometer's response into coincidence with the electrode.

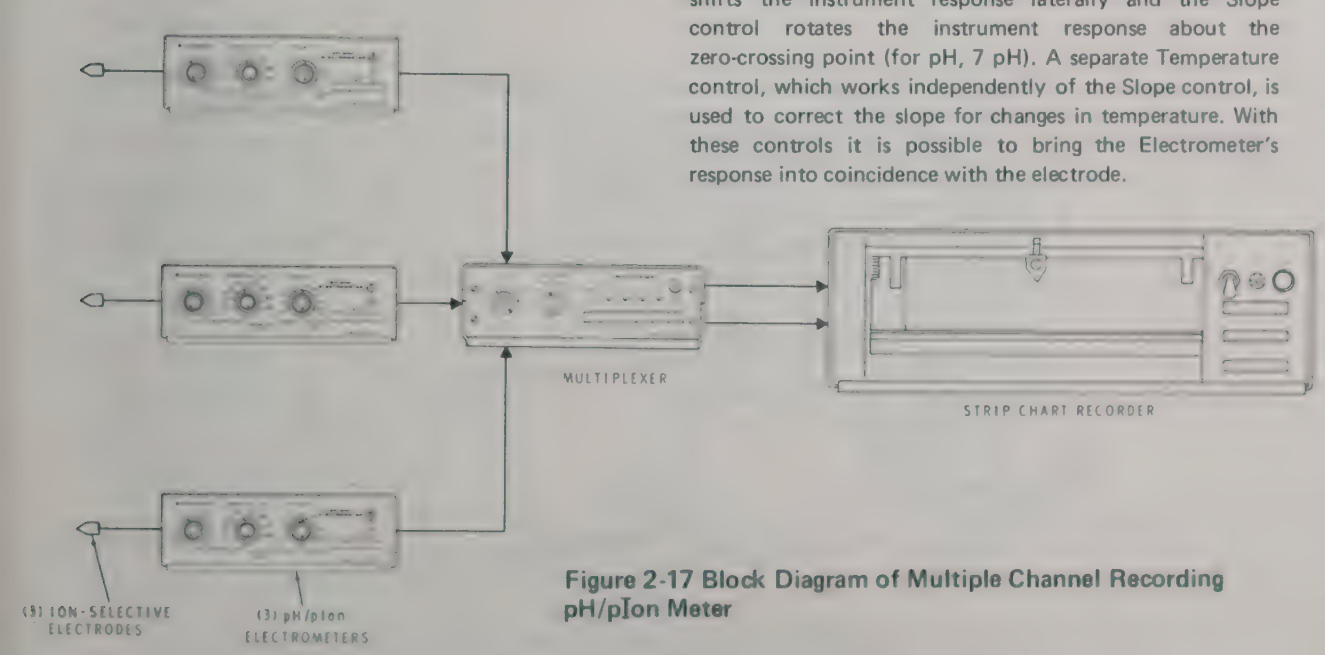

Figure 2-17 Block Diagram of Multiple Channel Recording pH/pIon Meter

The potential produced by each Electrometer is sequentially sampled by means of electronically programmed reed relays. As each channel is enabled, the data obtained is coupled directly to the Recorder and displayed. There are a small number of ion-selective electrodes that operate beyond the response conditioning capabilities of instrument (i.e. greater than 10,000 MΩ resistive). In these instances, interpolation of the output is required. For most ions for which there are suitable electrodes, the readout required is in terms of activity. Thus, these pIon values must be converted by the equation $pIon = -\log_{10} X_a$, where X_a is ion activity.

In order to observe individual pX indications, the Recorder pen is blanked between sample periods. This is accomplished through direct control of the Recorder by the Multiplexer.

SETUP PROCEDURE

Refer to Figure 2-18 and mount the Multiplexer and three Electrometers on the Recorder as described in Section 3 of this Manual. Plug the Electrometer line cords into the adjacent Electrometers and Multiplexer power receptacles as shown in Figure 2-18. Plug the Multiplexer line cord into the Recorder's (switched) power receptacle. The Recorder power switch is now the Master power switch. Connect the Multiplexer Output to the Recorder Input with the dual-banana cable supplied with the Multiplexer. Connect the Output of each Electrometer to the desired Channel Inputs on the Multiplexer with the dual-banana cables supplied with each Electrometer. The five-wire cable provided with the Multiplexer is connected between the Multiplexer Auxiliary Connector, and the Recorder Auxiliary Connector and Chassis Ground. Refer to the Inset illustration in Figure 2-18. This cable serves as a control interface to enable the Recorder pen during each window of the Multiplex scan. Connect the test electrode to either the BNC or Beckman jack and the reference electrode to the pin or banana jack, for each Electrometer. The pin and banana jacks, and the shells of the BNC and Beckman connectors are common internally. If a temperature probe (YSI* 700-series only) is used for automatic temperature compensation (ATC) connect it to the phone-type jack on the rear panel of the Electrometer.

NOTE: All ion-selective electrodes require special handling prior to, during, and after use. Refer to the instructions on "Care and Feeding" that accompany the electrode.

Mount each electrode to the side of a convenient Module with the electrode clamp assembly or use a ring-stand and test tube clamp. NOTE: The rest of the procedure will use pH as an example.

Switch all five modules ON. Hereafter, only the Recorder power switch need be operated. Enable the Multiplexer channels to be scanned and select the Scan Mode. If the Auto Mode is used, adjust the Auto Rate control for the desired sampling rate. If the External Mode is selected, a

*Yellow Springs Instrument Company

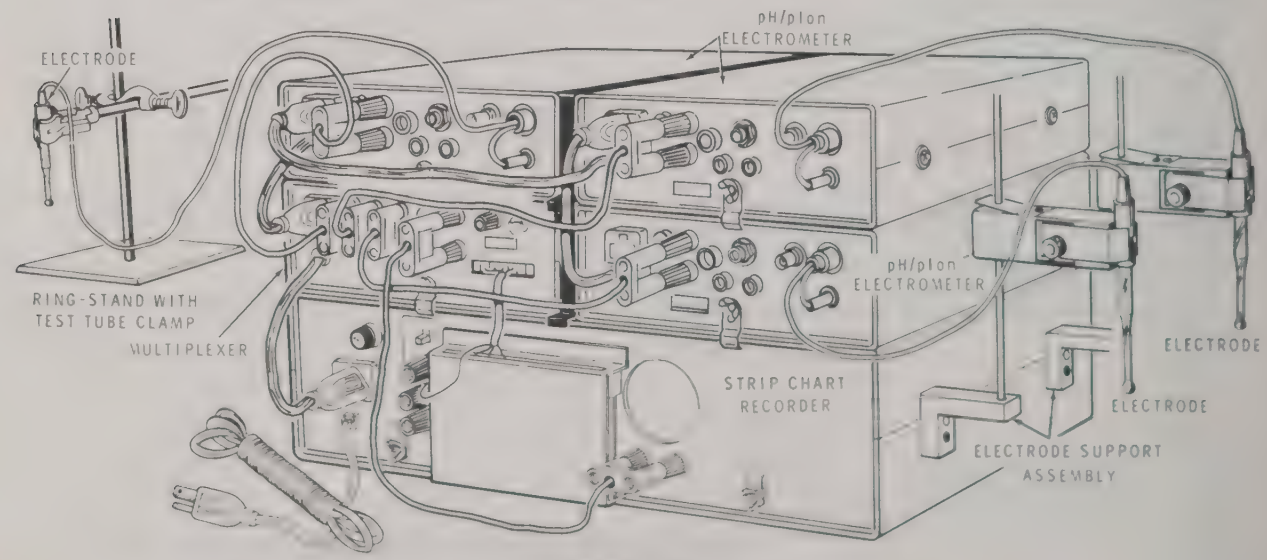

Figure 2-18

Rear panel interconnections required for operation as a multiple channel pH recorder.

TTL compatible signal must be connected to the Auxiliary Connector—External and Ground positions. On the Electrometers, switch the Anion—Cation control to Cation (pH). If a temperature probe is used, depress the ATC button; the lamp over the button will light. (CAUTION: Be sure that the probe is chemically inert to the solution under test.) If a temperature probe is not used, adjust the Temperature control to the solution's temperature. (The ATC button must be released.) Switch the Range/Volt Out switch to 10 pX and the Slope select to Theoretical (pH). The Slope control is switched out of the circuit by the Slope select. Temporarily switch the Multiplexer Mode to Manual and scan to Channel 1. Depress the Zero Set pushbutton on the Electrometer connected to Channel 1. Also, depress the Servo and Pen pushbuttons on the Recorder and adjust the Zero control for a pen deflection of zero. Release the Zero Set pushbutton. Place each electrode in a 7 pH standard buffer solution, manually scan each channel, and adjust each Electrometer Standardize control for a 7.00 pen deflection (7.00 pH). Return the Multiplexer Mode switch to the original position. NOTE: It is important to have the buffer and test solution at the same temperature.

Select the desired Chart Speed, depress the Chart pushbutton, and mark the chart for future channel I.D. reference.

When two or more Multiplexers are used, only minor modifications to the basic System are required. Each Multiplexer is connected to the next with the Cascade cable and chassis connector on the rear panel. The final unit that utilizes the chassis connector only is the Master Multiplexer. Recorder pen control and scan program are derived from the Master. The remaining Multiplexers in the String are switched to the Slave Mode. Connect the Outputs of the Slave units in parallel with the Master Output. Plug the Electrometers into the Multiplexer Inputs and enable the channels used, with the Channel Selector pushbuttons. The remaining operation is unchanged. NOTE: For greater resolution and versatility a DC Offset Module can be connected to each of the Electrometers.

SPECIFICATIONS

NOTE: These specifications are listed in terms of pH or mV. Specifications for pIon determination are dependent on the electrode used and the ion under investigation. In some instances, interpolation of the indication is required.

Range	0-14 pH. 0 to ±10 volts.
Maximum Input Voltage	10 volts.
Input Impedance	$>10^{12}$ Ω at 25°C.
Input Bias Current	0.5 pA at 25°C.
Drift	0.0015 pH/°C.
Resolution	0.025 pH. 2.5 mV.
Accuracy:	
pH	±0.003 pH (assuming the pH sample is within 3 pH units of the Standardization point).
mV	±0.3% of reading.
Line Stability	0.0001 pH/V.

Internal Programmer:	
Rate	Variable 1 to 0.05 samples per second.
Time Jitter	≤5%, typical.
External Programmer Input:	
Signal	TTL compatible, 5 samples per second maximum. (Logic 0 ≤0.4 volts. Logic 1 ≥2.4 volts but ≤5.5 volts.)
Maximum Rise Time	1 sec/volt.
Minimum Pulse Width	100 ns.
Aperture Time Error	≤1 ms referenced to the channel ID signal at the rear panel connector.
Recorder:	
Span	10 inches, calibrated 0-1 volt full scale.
Slidewire Linearity	0.1%.
Slewing Speed	20 inches/second.
Dead Zone	<0.1% of full scale.
Chart Speeds	Twenty-three speeds, selected by 6 pushbuttons: 2, 5, or 10 seconds per inch. Multiplier pushbuttons: x3, x10, and x60 may be used singly or in any combination.
Instrument Operating Temperature	10°C to 40°C ambient.
Power Requirements	105-125 Vac, 50/60 Hz, 59 watts maximum. (Can be rewired for 210-250 volt operation.)
Overall Dimensions	17-5/8" wide, 15" high, and 13-1/8" deep with writing panel in 45 degree position.

FEATURES

ELECTROMETER

Front Panel Controls:

Temperature Compensation	Manual or Automatic, 0°C to 100°C.
Standardize	8 turn, ±100 mV range.
Slope Control	20 mV to 115 mV/100 mV out.
Slope Switch	Theoretical pH or manual Slope control.

Zero Set	Shorts Recorder Out terminals.
Anion–Cation (pH)	Selects polarity of slope.

Rear Panel Connectors:

Expanded Recorder Output	1 pH, 2 pH, 5 pH, 10 pH, 100 mV, 200 mV, 500 mV, and 1000 mV for 1 V out.
Inputs	Universal (Beckman-type) and BNC for glass or ion selective electrode. Pin and banana jacks for reference electrode.
DVM Output	100 mV/pH, 100 mV/100 mV, and decimal point (D.P.) control.
Polarization	10 μA current for Karl Fisher Titration.
Versatile Electrode Holder	Accommodates glass and reference electrodes or a combination electrode.

MULTIPLEXER

Mode Switch:

Auto	Internal programmer, variable 1-20 seconds per sample.
External	TTL compatible, 5 pps maximum.
Slave	Cascaded with Master Multiplexer.
Manual	Front panel pushbutton control.

Auxiliary Connector:

Null Input	Recorder pen null data.
Pen Lift Output	TTL level 0 to lift recorder pen when channels switch.
Events Output	TTL level 1 indicates Channel 1 operation.
Channel ID Signal (A, B, C Output)	TTL level, BCD information.
Cascade Input (Cable Connector)	Slaved to Master Multiplexer switch rate.
Cascade Output (Chassis Connector)	Control data for Slaved Multiplexer (s).

RECORDER

Auxiliary Inputs:

External Chart Drive	EXT-INT switch, when in the EXT position, enables the chart drive to be synchronized with an external signal source. Refer to the EU-205-11 Manual for signal requirements.

Remote Servo Control	Connection of demodulator output to circuit ground (COM) with stop servo. NOTE: Up to ±4 volts at <1 mA may be applied to the grounding device.
Remote Pen Lift	Connection to chassis ground will lift pen. NOTE: Up to 0.7 volts <15 mA may be applied to the grounding device.
Remote Chart Control	Connection to chassis ground will stop chart. NOTE: Up to 5 volts at <40 mA may be applied to grounding device.
Pen Motor External Drive	Enables pen motor to be driven by external source. Requires 20 mV to start pen motion, and 100 mV for full speed operation. Input impedance 10 kΩ.

Auxiliary Outputs:

Slidewire	Enables slidewire to be connected to modules such as the EU-200-81 Servo Amplifier Patch Module.
Chart Drive Output	Enables external equipment (TTL compatible) to be synchronized to chart drive.
Calibrated Reference Supply	Both (+) and (—) sides of the floating reference supply are available. May be used as a reference source for such modules as the EU-200-81.
Zero Control	Enables the control to be used in external modules.
Servo "ON" signal	Chassis ground potential when Servo pushbutton is pressed in.
Chart "ON" signal	Chassis ground potential when Chart pushbutton is pressed in.
Null Signal Out	Minimum voltage (output) when pen reaches null point.

Section 3

MECHANICAL ARRANGEMENTS

In order to fully exploit the electrical versatility of the EU-200-Series line, a variety of mechanical arrangements are provided. Modules in the EU-200-Series can be stacked on top of other 200-series products and locked in place by a unique clamp arrangement, mounted in a Model SU-200-RM Rack Mount, or stacked on the Model SU-200-GB Gimbal Bracket.

EU-200-Series products are provided in two basic cabinet sizes. The EU-205-11 Chart Recorder is the only product packaged in the larger cabinet. The EU-200-91 Limit Detector is an example of the 1/2-width cabinet. See Figure 3-1B for a comparison of these cabinets.

Because of the unique clamp design, two or more 1/2-width modules can be stacked as a system, as in Figure 3-1A. The front plastic-covered edge of the top module must be placed over the top edge of the bottom module. Loosen the wing nut on the rear panel, position the rear catch under the top edge of the bottom module, and retighten the wing nut. Make sure the modules are centered so that the clamp will engage properly.

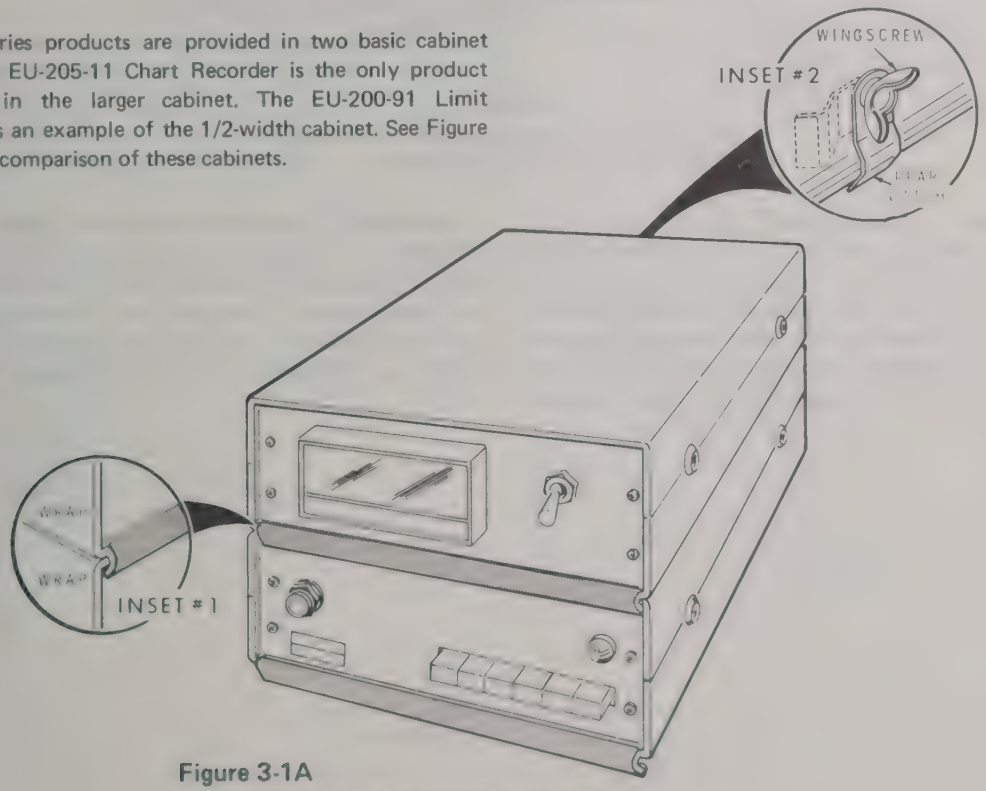

Figure 3-1A

Stacking 1/2-width 200-Series Modules as a system.

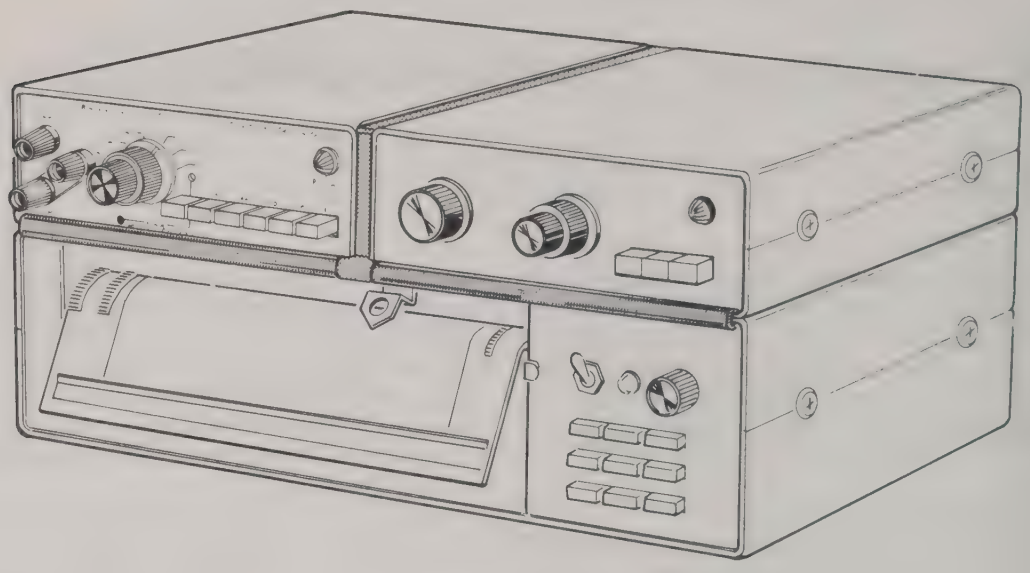

Figure 3-1B

Method used for stacking 1/2-width 200-Series modules onto an EU-205-11 Chart Recorder.

Each 1/2-width module is shipped with a black plastic C-shaped trim strip. This bracket serves as a divider when a pair of 1/2-width modules are stacked on an EU-205-11 Recorder, as in Figure 3-1B. Place a 1/2-width module on the top left side of the Recorder. Next, snap the front and rear edges of the trim strip onto the center of the top cover of the Recorder. Finally, install the other 1/2-width module on the recorder; center and press the two modules and trim strip together; and secure the modules with the two rear clamps. The trim strip is designed so that another trim strip can be connected to its top. Thus, a large number of module-pairs can be stacked and maintain a pleasant appearing, very versatile instrumentation assembly.

RACK MOUNTING

Where mounting in a 19" EIA standard rack is required, combinations of four 1/2-width modules or one EU-205-11 Recorder can be accommodated by the SU-200-RM Rack Mount Accessory (see Figure 3-1C). The cabinet is removed from each 1/2-width module, the modules are interconnected with a center bracket (included with the mount), and then secured in the mount. The EU-205-11 Recorder is easily secured in the mount, once the cabinet is removed. Because the Rack Mount is designed for a 19-inch equipment rack, it is easily installed or removed for various applications. Refer to the SU-200-RM Rack Mount Manual for a more detailed description of module installation.

In applications where only two or three modules are required, a Blank Module, Model SU-200-03, can be obtained as an option to fill the mount. As an added advantage, the Blank Module can be used to house a circuit of your own design for special applications.

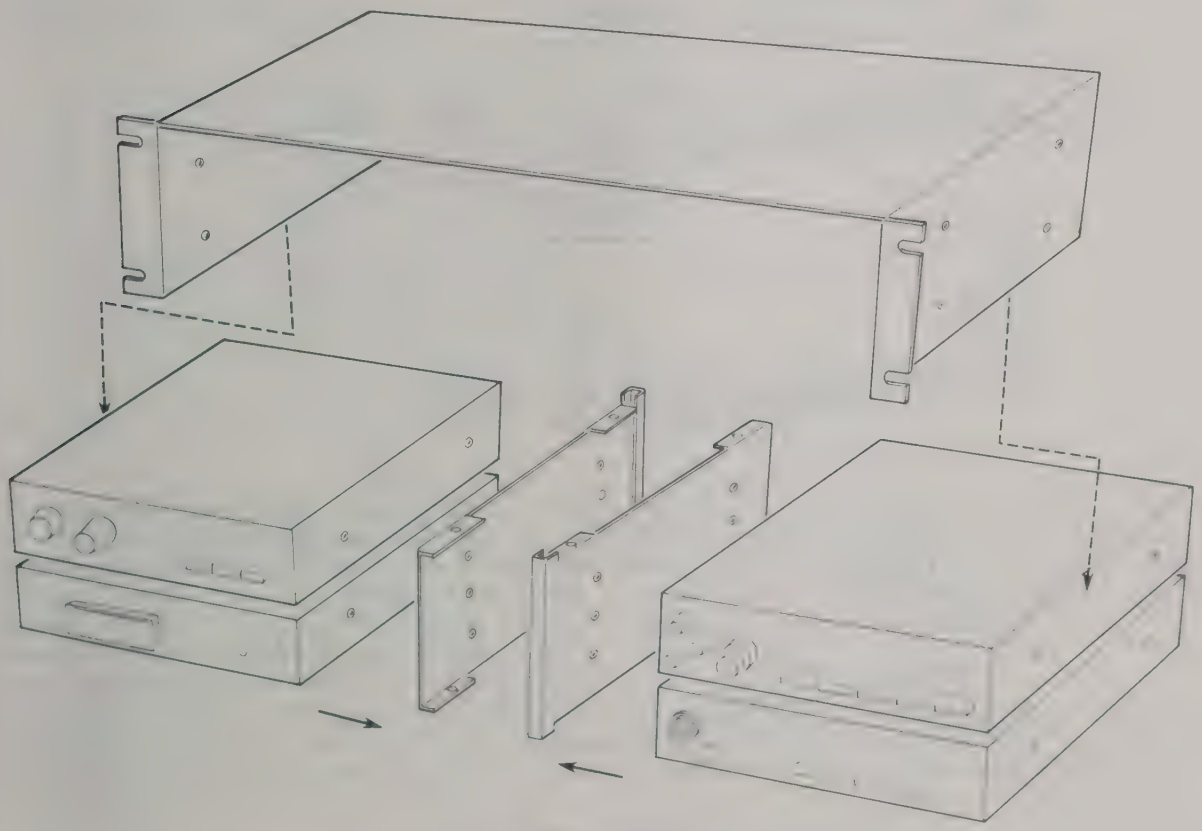

Figure 3-1C

Mounting four 1/2-width 200-Series modules in a 19 inch EIA standard rack.

GIMBAL BRACKET MOUNTING

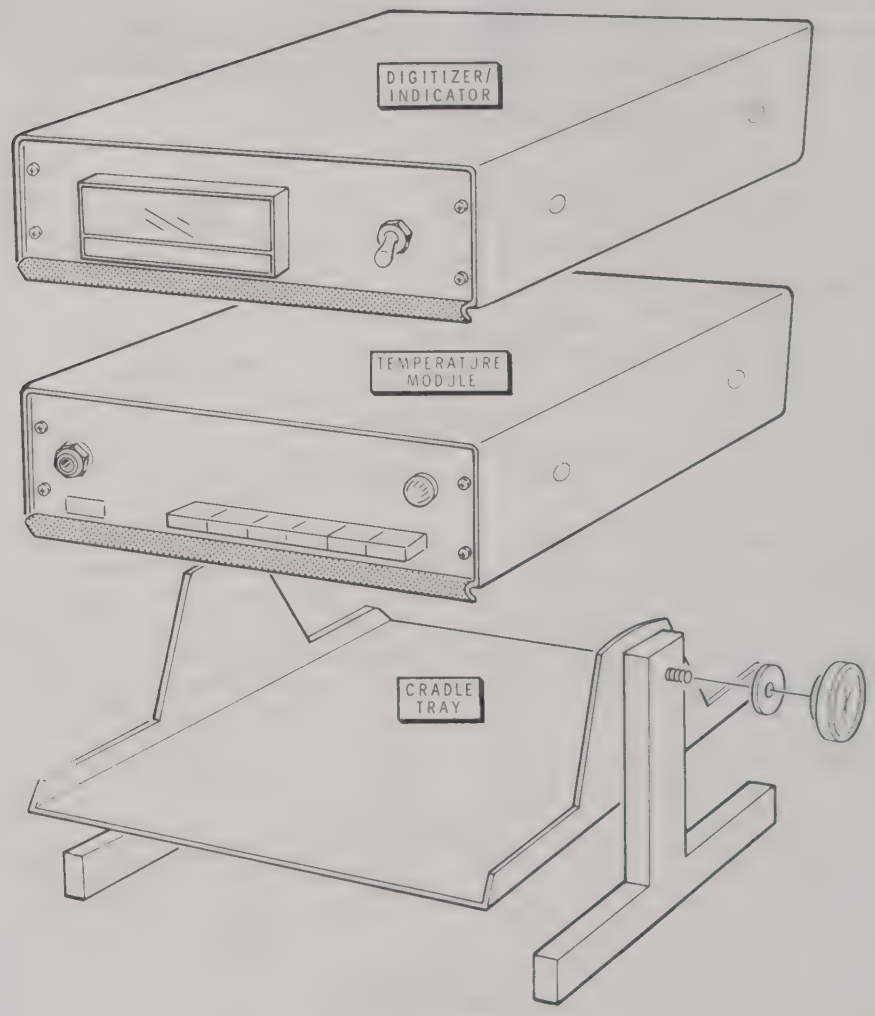

Figure 3-1D

Stacking 1/2-width 200-Series modules on a gimbal bracket.

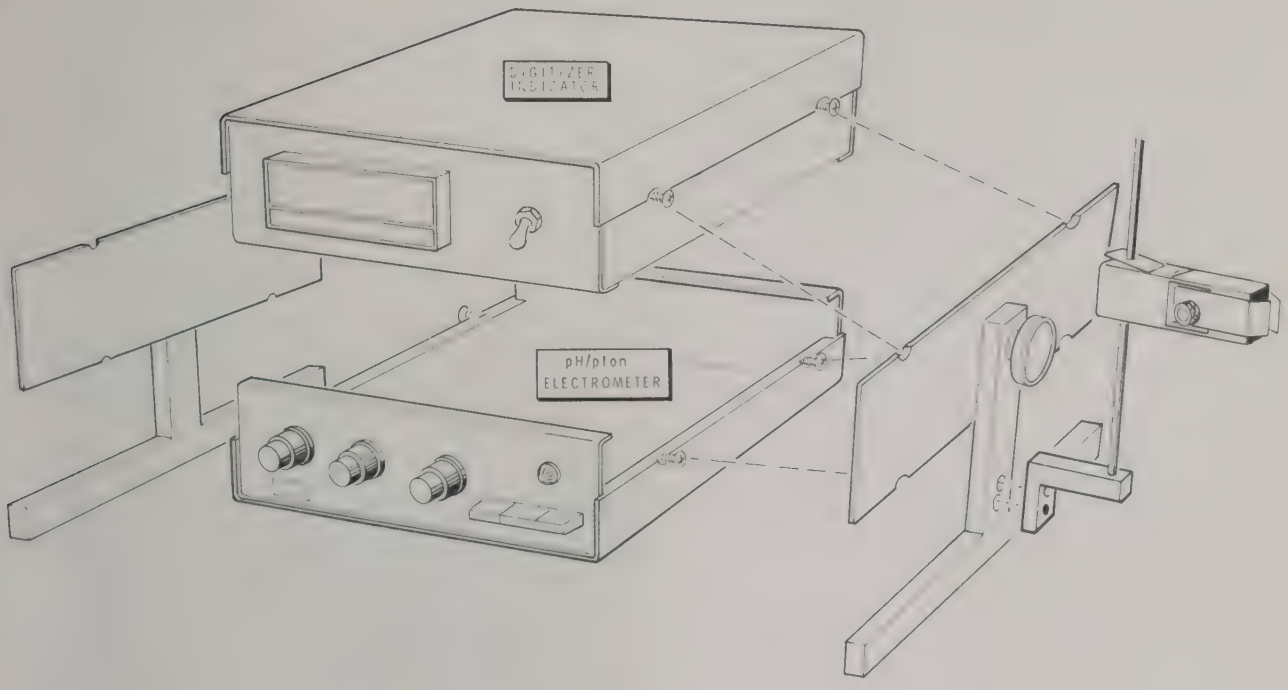

Figure 3-1E

Integrating two 1/2-width 200-Series modules with a gimbal bracket.

For many system applications it is very convenient to have the instrument mounted on a gimbal. This can be accomplished with the SU-200-GB Gimbal Bracket. The 1/2-width modules are mounted on the gimbal cradle-tray, as shown in Figure 3-1D, in a manner identical to normal module stacking. (No more than two or three modules should be stacked in this method.) Figure 3-1E illustrates the alternate method for utilizing the Gimbal Bracket. In this manner, two 1/2-width cabinets are integrated as a system (e.g. Digital pH/pIon Electrometer, etc.).

Refer to Figure 3-1E and remove the bottom cover from each module. Shift the top cover of one of the modules to the bottom of the module. Mount a side-plate and gimbal leg on each side of the bottom module. Then, secure the top module to the bottom module assembly.

As an added convenience, a probe support (for pH, etc.) can be mounted directly to one of the gimbal legs. The support is supplied with the module that requires its use.

SERVICE INFORMATION

The following Heath Company services are available if you need them: Replacement Parts, Technical Consultation, and Factory Service. Address all correspondence to:

HEATH COMPANY
Benton Harbor, Michigan 49022

For prompt service, use a separate letter for each department you write to.

Replacement parts and repair service are also available at your nearest Authorized Service Center or Heath Electronic Center. These Centers are listed in your Heath Catalog.

REPLACEMENT PARTS

If a replacement part is needed, please include the following information in your letter:

1. Part number and description.
2. Model Number and Series Number of the equipment.

If your equipment is in the Warranty period, add:

3. Date of purchase.
4. Nature of defect.

Heath Company will fill your order promptly. Please DO NOT RETURN PARTS unless they are requested. Parts that are damaged through carelessness or misuse by the customer will not be replaced without cost.

TECHNICAL CONSULTATION

You can write to our Technical Consultants for help with any Heath equipment, or for answers to any questions about the use of this equipment.

The completeness and accuracy of the advice mailed back to you depends entirely on the information in your letter. Be sure to include:

1. The Model Number and Series Number of the equipment (on blue and white identification label).
2. Date of purchase.
3. An exact description of the difficulty. Include switch positions, connections to other units, operating procedures, voltage reading, and any other information you think might be helpful.
4. List everything you have done in attempting to correct the difficulty.

FACTORY SERVICE

If you do not have qualified repair services at your disposal, you can return your equipment to the Heath Company Service Department to have it repaired for a minimum service fee. (Equipment that has been modified will not be accepted for repair.) Refer to Shipping Instructions for details on how to package and ship the equipment.

To be eligible for replacement parts under the terms of the Warranty, equipment returned for factory service must be accompanied by the invoice or the sales slip, or a copy of either. (If you send the original invoice or sales slip, it will be returned to you.)

SHIPPING INSTRUCTIONS

Check the equipment to see that all parts are in place. Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least three inches of resilient packing material (shredded paper, excelsior, etc.) on all sides between the equipment and the carton.

Seal the carton with gummed paper tape and tie it with a strong cord. Ship it by prepaid Express or insured Parcel Post to:

HEATH COMPANY
Benton Harbor, Michigan 49022

Attach a letter, containing the following information to the outside of the carton:

1. Your name and return address.
2. Date of purchase.
3. A brief description of the difficulty.
4. Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the Warranty.

WARRANTY

The Heath Company warrants that under conditions of normal use and service it will repair or replace any factory assembled unit whose performance does not meet published specifications and is returned to Heath prepaid within one year following date of shipment. The published specifications are those labelled "specifications" in the catalog and the manual for the unit. The replacement or repaired unit is shipped prepaid by us anywhere in the continental United States or to APO or FPO addresses. Shipments to other places are FOB factory. Heath's obligation is limited to such replacement or repair by Heath, and Heath is not responsible under this warranty or otherwise for any consequential damage or other loss in connection with the unit or its use.

Questions relating to repairs or warranty replacement in the continental United States (APO and FPO included) should be addressed to Heath Company, attention: Customer Relations, or the nearest Heathkit Electronic Center. In all other areas please contact the authorized Heathkit representative in your country, or Heath Company, attention: International Division.

HEATH COMPANY
Benton Harbor, Michigan 49022

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.

MP MASTER
MA22876